Intakes and main food sources of calcium for vegetarian and omnivorous New Zealand adolescent females

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Abstract

Background: Calcium is an essential mineral required to assist peak bone mass formation during adolescence. Calcium can only be obtained through the diet and is not widely spread throughout dietary sources with dairy products being the richest source. The last nationwide investigation of calcium intake data suggested that adolescent females were not meeting their calcium requirements, placing them at a high risk of developing osteoporosis in later life. Furthermore, vegetarian diets are becoming increasingly popular in this demographic group and, in some instances, can involve the limiting or avoidance of dairy products. The aim of the current study is to investigate the impact these food choices may have on dietary calcium adequacy and to provide updated data on the calcium intakes of adolescent females living in New Zealand.

Objective: To investigate the current calcium intake and food sources of vegetarian and omnivorous New Zealand adolescent females aged 15 – 18 years.

Design: A cross-sectional observational survey of female adolescents aged 15 to 18 years from eight different locations throughout New Zealand. Data was collected in two waves (February to April and July to September 2019). Questionnaires examining participant demographics, dietary intakes and habits (including vegetarianism) and dietary supplement use were self-administered via an online platform. Standing height and weight was measured by trained investigators to allow calculation of BMI z-scores. Dietary intake data was collected using 24-hr dietary recalls, completed on two separate occasions and entered into the dietary assessment software programme FoodWorks to calculate nutrient intakes. Usual calcium intakes were estimated using the multiple

source method and the prevalence of inadequate calcium intakes calculated by the Estimated Average Requirement (EAR)-cut-point method.

Results: The study recruited 279 participants, 79.1% were of NZEO ethnicity, 15.5% Maori, 9% Asian and 6% Pacific. Most participants self-reported as following an omnivorous food pattern (87.1%) while 12.9% self-reported as being vegetarian. The median (interquartile range) usual intake of dietary calcium for adolescent females was 711 (544, 925) mg/day. The prevalence of inadequate calcium intakes was high, with 84% of the study population not achieving the EAR for calcium. No difference in calcium intakes were identified between vegetarian and omnivorous diets. Almost all (97%) of vegetarian participants had inadequate calcium intakes, however, inadequate intakes were also prevalent among omnivore participants (83%). Milk was the greatest contributor to calcium intakes (17.4%) and participants who reported drinking milk more regularly, had higher mean usual calcium intakes. The type of milk consumed varied between omnivore and vegetarian participants with cow's milk more commonly consumed by omnivore participants and plant-based milks by vegetarian participants (81% vs 67.7%) with both groups more likely to consume whole/full fat options (76.3%).

Conclusion: These results suggest that calcium intakes of New Zealand adolescent females remain below recommended intakes, thereby increasing the risk of developing osteoporosis in later life. Milk remains the largest contributor of calcium to dietary calcium intake for both vegetarian and non-vegetarian adolescents. Following a vegetarian diet does not markedly increase the risk of inadequate calcium intakes in this sample population as the median usual calcium intakes were similar for both omnivore and vegetarian participants. The small number of vegetarian participants (12.9%) prevented examination of the calcium intakes of vegetarian participants who choose to

exclude all milk and dairy products (vegans). Given the major contribution dairy makes to the calcium intakes of adolescent females, further investigation regarding the dietary sources of calcium for vegans is warranted.

Preface

This research project is part of the larger SuNDiAL (Survey of Nutrition, Diet and Lifestyle) project, a nationwide study which aims to compare the dietary intakes and habits, nutritional status, health status, motivations, attitudes, and lifestyles of vegetarian and non-vegetarian adolescent females in New Zealand.

Drs Jill Haszard and Meredith Peddie from the University of Otago were responsible for study design, funding applications and obtaining ethical approval. Dr Jill Haszard was responsible for statistical oversight of the project. Dr Sue MacDonell provided academic supervision of the candidate and all investigators were from the Department of Human Nutrition, University of Otago. Data collection for the SuNDiAL Project was completed by 29 MDiet students in 13 secondary schools located across New Zealand. A full list of data collected is shown in **Figure 0.1.**

Data category	SuNDiAL data collected
Demographics	Age and sex
	Ethnicity
	Health related questionnaire
Attitudes and beliefs around food choice	Questionnaire*
	Dietary habits questionnaire
Anthropometry	Height
	Body weight
	Ulna Length*
Dietary assessment	Two 24-hour dietary recalls
	Nutritional supplement use
Biochemical status	Blood and urine samples*
Activity patterns	Sleep, sedentary behaviour and physical activity*

* Data collected by the candidate but not used in this thesis

Figure 0.1 All data collected for this thesis and the SuNDiAL project

The research undertaken in this thesis focuses on the calcium intakes of adolescent females aged 15 to 18 years and is part of the larger SuNDiAL project that will be carried on into 2020. The candidate was responsible for:

- Literature Search
- Recruited 27 participants at the allocated high school, including, development of a powerpoint presentation, presenting at an assembly and sending participant information to the project coordinator to gain consent
- Organizing a schedule with the high school and participants to enable data collection
- Collection of two 24-hour dietary recalls
- Collection of anthropometric data (height, weight and ulna length)
- Follow-up with participants to ensure completion of all on-line questionnaires
- Organizing, administering and collecting urine samples for delivery to the Phlebotomist
- Organizing a schedule and location for the Phlebotomist to collect blood samples
- Administering accelerometers and sleep diaries and collecting once completed
- Entering and editing dietary data into the nutritional analysis software programme, FoodWorks
- Interpretation of results
- Writing of all sections of the thesis

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To the team at **Mt Aspiring College** and **Deb Mcintosh** for being so welcoming, enthusiastic and supportive during our time in Wanaka. Knowing staff were supporting and encouraging students to sign up to the SuNDiAL project made our job's so much easier.

MDiet class of 2018/19 thank you all so much for the love, the support and most of all, the laughs. It has been an absolute pleasure to share the previous two years with you and I cannot wait to see what the future holds for you all.

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List of Abbreviations

24hrDR	24-hour diet recall
ANS 08/09	Adult nutrition survey 2008/09
BMD	Bone mineral density
CI	Confidence interval
EAR	Estimated average requirement
FFQ	Food frequency questionnaire
ICC	Intra-class correlation coefficients
IOF	International Osteoporosis Foundation
MSM	Multiple Source Method
NRV	Nutrient reference value
PI	Principal Investigator
PTH	Parathyroid hormone
RDI	Recommended daily intake
REDcap	Research electronic data capture
SD	Standard deviation
SDA	Seventh day Adventist
SuNDiAL	Survey of nutrition, diet and lifestyle
UL	Upper limit

1. Introduction

Calcium is an essential mineral required by a number of systems in the human body. Not only is calcium essential for the health of bones and teeth, it also has a role in muscle and nerve function, hormone function and production and blood clot formation (1, 2). Calcium cannot be synthesized by the human body and therefore it must be obtained from the diet through food or supplements (3).

Adequate calcium intakes are important at every age, however, adolescence is a particular period of nutritional vulnerability due to the increased requirements of calcium for bone and muscle growth and development (4). Other factors not specifically related to adolescence such as smoking, a low vitamin D status and high intakes of caffeine, salt and protein can cause calcium to be lost from the body (5). The most recent national data for New Zealand female adolescents showed mean intakes (682 mg/day) were well below the estimated average requirement (EAR) of 1050 mg/day (6). Furthermore, there was a high prevalence (87.8%) of inadequate calcium intakes (6). This inadequacy was a large increase from the previous National Nutrition Survey in 1997 where only 37% of female adolescents had inadequate intakes (6). While this increase can be partly explained by a 60mg/day increase in the EAR between surveys, (5), other factors including an increase in dietary patterns which exclude dairy products and a greater awareness of lactose intolerance may be also be contributing factors (7).

Calcium reserves in the human body are stored in the skeleton and the size of this reserve is directly affected by calcium balance which is dependent on calcium intake and absorption and calcium losses. Inadequate dietary intake causes calcium to be mobilized from bones, leaving them weakened and increasing the likelihood of developing osteoporosis in later

life (5). Osteoporosis is a common disease in all western cultures and is one of the major causes of morbidity amongst New Zealand postmenopausal women (5).

Calcium is not widely distributed throughout food groups and is found mainly in milk, cheese and other dairy products (5, 6). Vegetarian diets may influence calcium needs due to higher intakes of phytates and oxalates which are known to inhibit calcium absorption (5, 8, 9). Lacto-ovo-vegetarians, who include dairy products in their diets, do appear to have similar or even higher calcium intakes than omnivores (5, 10). The more food groups that are excluded from the diet, the greater the risk of nutrient inadequacies. Vegan diets appear to have a higher risk of inadequate intakes compared to omnivorous diets due to the exclusion of animal products including calcium rich milk and dairy products (9, 11, 12), thus placing them at higher risk of fracture (13). Well planned vegan diets can attain calcium balance by ensuring other sources of calcium such as fortified plant-based milks and cereals, and legumes are consumed (5, 14).

This study aims to describe both the calcium intakes and the prevalence of inadequate calcium intakes among adolescent females in New Zealand, Furthermore, it will investigate whether diet status (vegetarianism) contributes to the risk of inadequacy. These results will contribute to increasing the understanding of calcium intakes and dietary sources of calcium from both omnivorous and vegetarian diets among an already at-risk population.

2. Literature Review

This literature review examines calcium nutrition, with a focus on the dietary intakes and calcium requirements of adolescent females. The role of calcium in growth and development at this life stage is also investigated, along with differences in calcium intakes between vegetarian and omnivores. A search of Scopus, Ovid and Google Scholar between 4th of September 2018 to 26th of November 2019 was conducted using the search terms listed in **Table 2.1**. Additional papers were sourced from the Ministry of Health, Osteoporosis Foundation and the World Health Organisation. In total 85 papers were identified and screened. Papers were excluded if they were not in English or were published prior to 1989.

Table 2.1 Keywords used in literature search

Keywords
Calcium
Adolescent females
Teenage
Intake
Vegetarianism
Non-vegetarian
Omnivore
Meat eaters
Cow's milk
Plant-based milk
Fortification
New Zealand
Sources
Requirements
Inadequate intake
Osteoporosis
Peak bone mass
Bioavailability
Homeostasis

2.1 Calcium Metabolism and Homeostasis

2.1.1 Calcium Function

Calcium has numerous roles in the human body but is most commonly associated with the formation and metabolism of bone (1). The majority of total body calcium (>99%) is stored in the bone as hydroxyapatite, a calcium-phosphate complex which provides structural rigidity of bones, and thus allows for movement of the body (1). The skeleton also acts as a store of calcium which is used to maintain intra- and extra-cellular calcium pools. Serum calcium represents the remaining 1% of total body calcium and is comprised of free ions, protein-bound complexes and ionic complexes. Serum calcium is in constant exchange with calcium pools (bone), as it is responsible for a range of essential functions, including extra- and intra-cellular signaling, nerve impulse transmission and muscle contraction (2). Although this pool of calcium is quantitively low, it is responsible for critical bodily functions, and is therefore tightly regulated (1).

2.1.2 Calcium and Bone Health

The link between adequate calcium intake in the diet and positive bone health has been well established as without adequate intakes, it is not possible to build or maintain a normal skeletal mass (15). Bone turnover is influenced largely by nutrition, smoking, excessive alcohol intake, physical inactivity and other factors as shown in **Table 2.2**.

Table 2.2 Factors that affect bone health (16-18)

Factors affecting bone health;
Calcium and Vitamin D in the diet
Physical activity
Tobacco and alcohol use
Gender
Age
Race
Eating disorders
Low body weight
Medications

Bones increase in size and mass during periods of growth such as adolescence, with peak bone mass achieved between the years of the early and late 20's (19). Research shows that if a low peak bone mass is achieved during adolescence, there is a higher risk of osteoporosis developing in adulthood (16, 20). Thus, the higher the peak bone mass, the larger the calcium reserve and the longer the delay of damaging bone loss in later life (17).

When assessing the effect of calcium on bone health in adolescence, bone mineral density (BMD) is most commonly used as fragility fractures are uncommon in this age group (21). Results from randomized control trials that involve adolescents using supplements or dairy-supplemented foods to increase calcium intakes, revealed that calcium has a positive effect on bone health as evidenced by an increase in BMD (9, 21). It has also been shown that when baseline habitual calcium intake is low, larger increments in BMD occur with increased dietary calcium intake (22) and these beneficial effects are likely to be sustained (23). When baseline calcium intake is adequate, BMD is increased with a higher calcium intake, but in smaller increments.

2.1.3 Bioavailability

Bioavailability is the proportion of a dietary nutrient that is potentially absorbable in a food source. Calcium bioavailability is dependent on a number of factors. Physiological factors such as hormones play a major role in calcium absorption (3) however certain foods also have an effect. For example, calcium may be poorly absorbed from foods containing oxalic and phytic acids while foods high in phosphorous improve calcium absorption (5, 9, 24). Supplement use is a popular method used to obtain desired calcium requirements however bioavailability is dependent on the type of supplementation, the dose and the timing of when

the supplement is consumed (5). Calcium carbonate is the most common form of calcium supplement and it is recommended to be taken with food as it requires stomach acid for absorption. Conversely, supplements in the form of calcium citrate are soluble and, therefore, can be taken without food. The percentage of calcium absorbed from supplements is dependent on the total amount of elemental calcium that is consumed in a dose; as the amount increases, the percentage absorbed decreases (4). A dose that contains less than 500 mg is preferred as this provides the highest absorption rates (4). The amount of calcium that is eliminated via sweat, urine and feces can also be affected by other factors such as high sodium and protein intakes which increase urinary calcium excretion (25, 26). High caffeine intake has been shown to increase calcium excretion and decrease absorption however moderate intakes (400 mg/day) have no negative effect on bones (27).

2.1.4 Calcium Homeostasis

Calcium cannot be produced by any biological process, it can only enter the body through the diet (3). Bones act as a store for calcium, releasing calcium when serum concentrations drop too low (3). This process is regulated by parathyroid hormone (PTH), vitamin D and calcitonin. As such, serum calcium concentrations are tightly controlled to remain between 8.8 – 10.4 mg/dL (28) as shown in **Figure 2.1.**

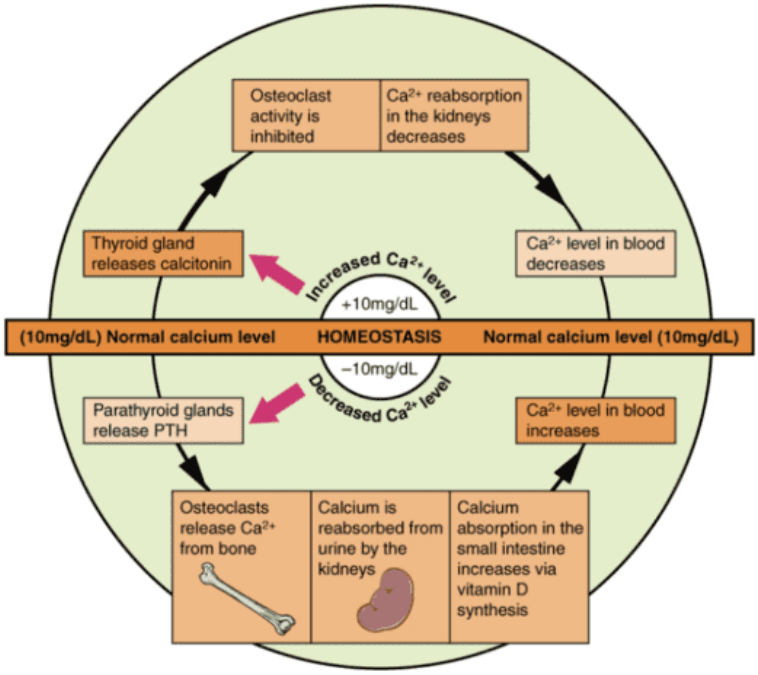

Figure 2.1 Pathways in calcium homeostasis

The body regulates calcium homeostasis with two pathways; one is signaled to turn on when serum calcium levels drop below normal range and one is signaled to turn on when serum calcium levels exceed the normal range. (3).

When the serum concentration of calcium decreases, the parathyroid gland signals the release of PTH which promotes reabsorption of calcium by the kidney; stimulates osteoclast proliferation and resorption; and increases absorption from the small intestine (29), thereby increasing the serum concentration of calcium. As serum calcium concentrations begin to rise, the negative feedback mechanism causes the calcium receptor to turn off and PTH secretion to be reduced (3). Calcitonin, a hormone produced in the thyroid, is also released which suppresses osteoclast activity, decreases renal reabsorption of calcium and subsequently decreases the level of serum calcium (3).

2.2 Calcium Nutrition

2.2.1 Nutrient Reference Values

The current Nutrient Reference Values (NRVs) for Australia and New Zealand define the amount of each nutrient which safely prevents the development of nutrient deficiencies in a given population group (30). **Table 2.3** outlines the NRVs for calcium for adolescent females; the estimated average requirement (EAR); the recommended daily intake (RDI); and the upper limit (UL) (30). The EAR meets calcium requirements of half of the healthy population of a particular sex and age and can therefore be used to estimate the approximate probability of inadequacy among a population. Adolescence is a time of dramatic bone growth where 37-45% of total skeletal bone is acquired to achieve peak bone mass (4). The current EAR provides for the increased rate of skeletal calcium accretion which occurs during adolescence and aims to achieve a positive calcium balance of 440 mg/day (5). Calcium balance is calculated by subtracting faecal, urinary and sweat losses from dietary intake while allowing for calcium retention and accretion (31). The UL of calcium is 2,500 mg/day, however, the effect of excessive intakes is not well established. Intakes exceeding the UL from dietary sources alone are rare. Excessive intakes over the UL are associated with hypercalcemia and hypercalciuria and may also be related to poor iron and zinc absorption as well as an increased risk of nephrolithiasis (1, 4).

Table 2.3 Nutrient reference values of calcium for adolescent females (5)

NRV[1]	mg/day
Estimated Average Requirement (EAR)	1050
Recommended Daily Intake (RDI)	1300
Upper Limit (UL)	2500

NRV Nutrient Reference Value

2.2.2 Dietary Assessment of Calcium Intakes

Dietary assessment methods include food recalls, weighed and estimated food records and food frequency questionnaires (FFQs). Each method has individual strengths and limitations (**Table 2.4)** and all methods run the risk of inaccuracy due to measurement errors and inter and intraindividual variability of intake (32). It is therefore important to consider bias and other variables leading to inaccurate results.

Table 2.4 Strengths and limitations of dietary assessment methods

Method	Strengths	Limitations
FFQ (32)	• Less expensive • Represents habitual intake • Preferable for high day to day variables • Self-administered • Suitable for large group studies • Ranks individuals according to intake	• Requires literacy • Less sensitive to measures of absolute intake for specific nutrients • Foods might not represent respondent and some foods might not be on FFQ • Relies on subjects' memory and interpretation (if self-conducted)
Food record (33)	• Does not rely on memory (recording as eating/drinking) • Used as a reference in calibration or validation studies • If weighed provides exact portion sizes • Easily applied to diverse groups • Covers wide range of eating habits • Suitable in metabolic and intervention studies	• Relies on subject reporting accurately • High subject burden • Does not capture true representation of ones' diet • Requires subjects to be literate can be complex • Subjects may alter diet/under or over report • Not practical for large population studies • Focused on short term intake
Food Recall (34, 35)	• Assess total dietary intake • Describes a populations intake • Serial recalls can estimate individual and community usual intakes • High precisions, improves with increased number of 24hr recall conducted in same subject • Can be conducted in low literacy populations	• Relies on participants memory • Reflective of 24-hrs only does not account for day-to-day variation in the diet • Depends on interviewer's capacity to describe ingredients, portions, dishes • Requires well trained interviewer • Tends to underestimate intake • Limited by food composition tables available • More suitable for adolescents if repeated

FFQ, food frequency questionnaire.

The 24-hour diet recall has been established as the most appropriate method for nutrition surveillance of population health for adolescents (35). The 24-hour dietary recall is a quantitative record of food and beverage consumption over the previous 24 hours and can be self- or interviewer administered (34). Due to daily variation in intake, a single 24-hour dietary recall is not considered to be a true representation of an individual's usual intake. This method, therefore, is often repeated in duplicate to account for the day-to-day variation in intake, to gain a better understanding of a participant's usual intake (34). Dietary recalls and FFQ are the main dietary assessment methods used to asses calcium intakes (35).

2.2.3 Dietary Calcium Intakes of Female Adolescents

Recent research regarding the dietary calcium intake of New Zealand adolescents is limited. The 2008/09 New Zealand Adult Nutrition Survey (ANS 08/09), reported a median intake of calcium for adolescent females aged 15-18 years of 682 mg/day. This median intake was lower than the previous 1997 National Nutrition Survey median intake of 740 mg/day (5). In the ANS, Maori and Pacific adolescent females had a lower median intake when compared to New Zealand European females of the same age (527 mg/day, 571 mg/day and 706 mg/day, respectively). No association between calcium intake and socioeconomic status was detected in the ANS 08/09 when adjusted for age, sex and ethnicity.

The most recent national estimates of the prevalence of inadequate calcium intakes of New Zealand adolescent females is now 10 years old. Nevertheless, most New Zealanders over 15 years of age did not meet the EAR with the prevalence of inadequacies increasing substantially between 1997 (37%) and 2008/09 (87.8%) (6). Between the two survey periods, the NRVs for calcium increased from 625 to 1050 mg/day to adjust for the loss of calcium in sweat (36). This change may have contributed to the rise in inadequate intakes

(6). However, changes in food patterns such as increasing popularity of veganism and perceived lactose intolerance (7, 15) warrants further detailed examination of calcium intakes in New Zealand adolescent females.

The dietary requirements for calcium intake set by each country vary due to differences in physical activity levels, vitamin D status and habitual levels of intake (6). Worldwide, dietary calcium intakes ranged from 540 mg/day to 1183 mg/day with research concluding most intakes for adolescent females were below calcium recommendations (37-39). Subsequently, the prevalence of inadequate calcium intake in Western countries is high and ranges from 69 – 95% (40-42). **Figure 2.2** presents results from a systematic review of calcium intakes around the world, conducted for the International Osteoporosis Foundation (IOF) (39). Seventy-four countries provided data regarding calcium intakes, however, it should be noted that intakes were for males and females and age groups varied considerably from 2 to 101 years (39). Most surveyed countries in south, east and southeast Asia had low dietary calcium intake (<400 mg/day). These countries also had suboptimal vitamin D status (39). Most surveyed countries in Africa and South America had moderately low calcium intakes (400-700 mg/day), whereas countries with a mean calcium intake above 1000 mg/day were all in Northern Europe (39).

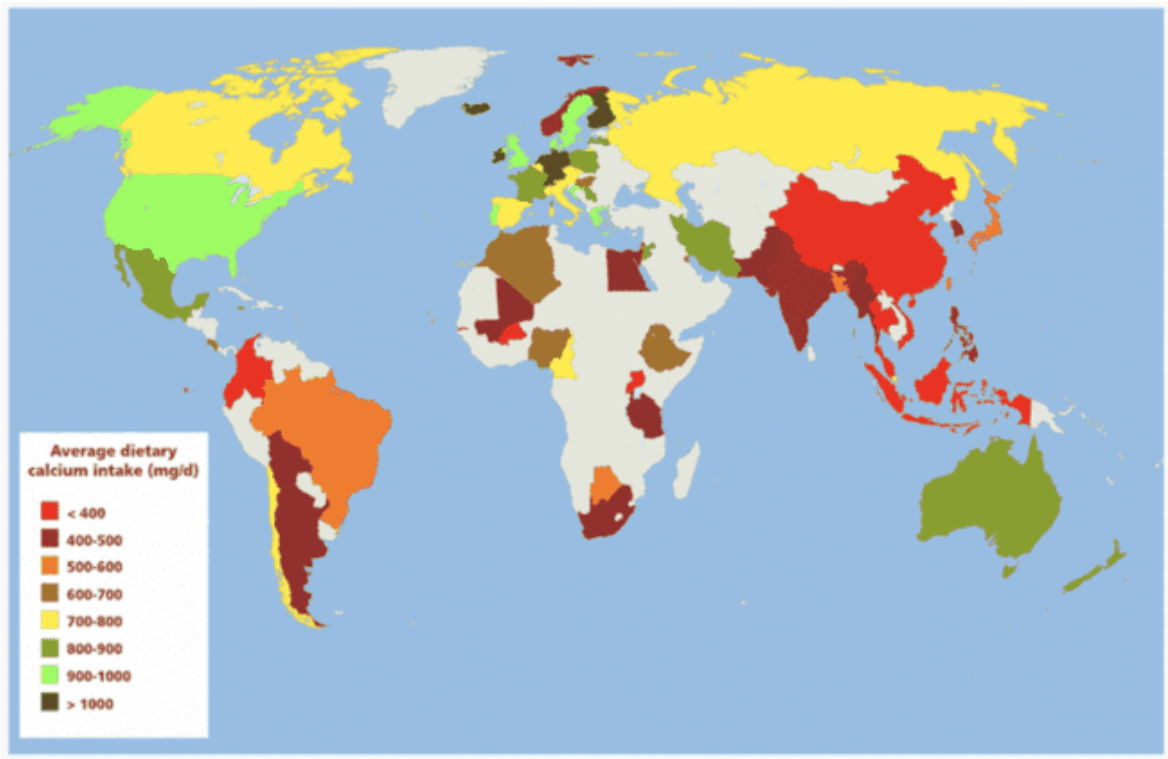

Figure 2.2 Global map of average dietary calcium intake categories *(43 accessed 06/11/19)*

2.2.4 Dietary sources of calcium

Calcium is not widely distributed across food groups. Evidence shows milk and other milk products are the largest contributor to dietary calcium intake, with limited evidence regarding dietary calcium intakes from non-dairy sources. Dairy, in particular milk, is the main source of calcium for New Zealand female adolescents, providing almost 20% of the total daily calcium intake (6). Smaller contributions are made by bread, non-alcoholic beverages, grains and pasta and vegetables as shown in **Table 2.5.** Calcium fortification is common in New Zealand food products such as plant-based (soy/almond) milks, cereals, breakfast juices and tofu. The contribution of these foods to total calcium intake, however, has not been quantified.

Calcium consumption, particularly from milk, declines throughout adolescent years (41, 42, 44). This decline may be due to carbonated beverages and other energy dense

alternatives displacing dairy products (15, 39, 42). The decline may also be related to a lack of knowledge regarding recommended servings or avoidance due to the misconception that dairy products are fattening (45). However, a wider investigation of the dietary habits of this age group is required to draw a clear conclusion to be drawn.

Dietary sources of calcium are similar throughout the world with the largest calcium contributor being dairy products (milk, cheese and yoghurt) (1, 42, 46). Populations that do not consume dairy products obtain calcium through alternative calcium containing foods such as, canned fish, green leafy vegetables, nuts and seeds, fortified plant-based milks and supplementation (6, 46). While the New Zealand Ministry of Health nutrition guidelines encourage milk and milk products to be included every day (47), guidelines in Canada updated at the beginning of 2019 differ. These new Canadian guidelines no longer recommend milk products due to the impact of dairy farming on the environment and instead focus on encouraging unprocessed foods through eating plenty of vegetables and fruits, wholegrain foods and protein foods (48). A recent study in Canada revealed >20% of total calcium and vitamin D intakes were sourced from milk products (49) raising concern about how the new guidelines will influence the intake and risk of calcium inadequacy in the Canadian population. Due to these recent changes in dietary guidelines, the risk of calcium inadequacy warrants further investigation over the next several years.

Table 2.5 shows the major dietary sources of calcium for New Zealand adolescent females and the changes in contribution between the 1997 and 2008/09 national nutrition surveys. While milk remained the largest contributor of calcium in 2008/09 for female adolescents, this age group continued to consume the least amount of milk when compared to older age groups (21.8% - 31.7%) (6). The smaller contributions to total calcium intake of milk and

cheese may be due to a decreased intake in dairy products resulting in greater reliance on other sources such as bread, non-alcoholic beverages, grains and pasta (6, 7).

Table 2.5 Contribution of dietary sources to total calcium intake of adolescent females in New Zealand (6)

	Percent Contribution to Total Calcium Intake (%)	
Dietary Source	**1997**	**2008/09**
Milk	31	19
Bread	6	10
Non-alcoholic Beverages	7	10
Cheese	11	7
Grains and Pasta	4	6
Dairy Products	7	7
Vegetables	4	4

2.3 Vegetarian Eating Patterns

2.3.1 Definitions of vegetarianism

Vegetarian eating patterns consist mostly of plant-based foods including fruits, vegetables, legumes, nuts, seeds and grains. Animal products are generally excluded but the extent of exclusion depends on the individual and their motivation for choosing a particular eating pattern (50, 51). Similarly, classification of vegetarianism also determines the extent of exclusion (52, 53) (**Table 2.6).**

Table 2.6 Types and definitions of vegetarianism (52, 53)

Type of Vegetarianism	**Definition**
Lacto-ovo-vegetarian	Consumes dairy products and eggs but no meat, poultry, or seafood
Lacto-vegetarian	Dairy products but not eggs, meat, poultry, or seafood
Ovo-vegetarian	Eggs but no dairy products, meat, poultry, or seafood
Veganism	No animal products, including meat, fish, poultry, eggs, and dairy products; many vegans will also avoid honey
Pollatarian	Poultry but not red meat or fish and seafood
Pescatarian	Fish and seafood but not red meat, white meat or fowl
Flexitarian	Limit but do not exclude meat entirely. Mostly plant-based but not exclusive

2.3.2 Prevalence of vegetarian eating patterns in New Zealand

There is little evidence available that describes the prevalence of vegetarianism in New Zealand and what does exist, arises from marketing and social surveys. On this basis, there have been claims that vegetarianism is becoming more popular. For instance, in 2002 Bidwell et al claimed that as few as 1-2% of the population considered themselves to be vegetarian (54). A later market research survey by Roy Morgan, revealed a 27% rise in vegetarianism over a four-year period; up from 8.1% of the population in 2011 to 10.3% in 2015. The largest increase was seen in the 14 to 24-year-old age group (55). Similarly, a Colmar Brunton sustainability report claimed one in ten New Zealander's reported themselves going 'mostly' meat free in 2018, an increase of 3% over the preceding year (56).

2.3.3 Factors which influence vegetarian eating patterns among adolescent females

Plant-based foods were predominant prehistoric food sources due to a lack of animal food, an inability to catch animals or both (57). More recently, the choice to follow a vegetarian diet is influenced by a range of reasons including age, gender, religion, education level, ethical beliefs and perceived health benefits (51, 58).

Improved health outcomes have been identified as a main motive for choosing a vegetarian diet (59). Furthermore, individuals who do not necessarily identify as vegetarian but who reduce meat consumption also note health benefits as motivators for this change (60, 61).

Abstinence from the consumption of meat and other animal products is an element of some religious practices such as Buddhism and Seventh Day Adventists (SDA). SDA represent a

religious group that forbids the use of tobacco, and the consumption of alcohol and pork. Adherence to a lacto-ovo-vegetarian diet is also encouraged (62).

Vegetarian eating can also be influenced by ethical and environmental reasoning where individuals consider avoidance of animal products as a moral imperative to prevent harm to animals (63). In the only study to examine what factors influence adolescent females to follow vegetarian diets, Pribis *et al*. (51) investigated whether reasons for adopting a vegetarian lifestyle differed between generations of SDA. This cross-sectional, observational study found that younger (11-20 years) SDA females were motivated more by moral (that it is wrong to kill animals), and environmental reasoning, whereas older age groups were influenced by health reasons (51). Similarly, vegetarians have expressed greater consideration around ecological and health themes in relation to food, considering these to be more important when compared to meat eaters (64).

Adolescence is a time where individuals gain greater autonomy (65) and the motivation for choosing vegetarian diets may not be static with initial motivations being lost and/or new ones added (53). Consequently, the psychology of food choices made by adolescent vegetarians, may not be as simple as solely ethical or health beliefs. Ethical concerns, parental preference, health, gustatory and environmental factors are likely to interweave and influence their dietary habit (66). Vegetarian girls have also been identified as being more weight and body-conscious when compared to meat eaters (66) and perceive meat as promoting weight gain. Consequently, vegetarian eating patterns may also be adopted to restrain eating and, as such, may mask some types of disordered eating patterns (53, 67).

2.3.4 Risks and benefits of vegetarian diets

Adolescence is a crucial period of physical growth. During the adolescent 'growth spurt' teenagers attain approximately 15% of their final adult height and 45% of the maximal skeletal mass (68). For puberty to begin, an individual's skeletal age must be approximately 11 years for girls and 13 years for boys (68). Many studies have assessed the nutritional adequacy of vegetarian diets and most have shown that well planned vegetarian/vegan diets are able to supply the nutrients required for good health (9, 10, 69, 70). There are still concerns, however, that some nutrients may be deficient in poorly selected and unfortified diets, especially where there is increased nutritional requirements or limited food choices (71, 72). The risk of inadequate nutrient intakes varies with different vegetarian eating patterns (**Table 2.7)**. The greater the number of food groups that are excluded, the greater the risk of insufficient nutrition and therefore deficiencies.

Table 2.7 Avoided foods and reduced nutrient intakes of different vegetarian diets (70, 73-75)

Avoided Food	Types of Vegetarianism	Reduced Nutrient intake
Red meat	• Lacto-ovo-vegetarian • Lacto-vegetarian • Ovo-vegetarian • Pollatarian • Pescatarian • Veganism	• Vitamin B12 • Iron • Zinc • Animal protein
Fowl	• Lacto-ovo-vegetarian • Lacto-vegetarian • Ovo-vegetarian • Pescatarian • Veganism	• Vitamin B12 • Protein
Fish	• Lacto-ovo-vegetarian • Lacto-vegetarian • Ovo-vegetarian • Veganism	• Iodine • Omega-3 fatty acids
Eggs	• Lacto-ovo-vegetarian • Veganism	• Protein • Vitamin D • Vitamin A
Dairy products	• Veganism	• Animal protein • Calcium • Iodine • Vitamin B12, B2, D and A

The most likely nutrients to be deficient in an unbalanced vegetarian diet are protein, iron, vitamin D, B12 and omega-3 fatty acids (76). More restrictive forms of the vegetarian diet such as veganism, also threaten nutrients such as calcium and zinc (9).

Extensive research suggests vegetarian diets that are high in vegetables and fruit, wholegrains, fish and poultry, nuts and legumes and low-fat dairy products support positive bone health (77-81). Calcium intakes of lacto-ovo-vegetarians are reported as being similar or even higher than those of omnivores (9, 70, 82). Conversely, those following a vegan diet are at risk of lower calcium intakes and subsequent lower bone mineral density (5, 11, 12, 69, 82) due to the exclusion of dairy products such as milk, cheese and yogurt (14, 83).

As noted earlier, calcium is required for skeletal strength and rigidity and inadequate intakes are associated with bone fracture and a greater risk of developing osteoporosis later in life (84). The EPIC-Oxford study revealed that the fracture risk for lacto-ovo-vegetarians and omnivores between 20 and 89 years of age was similar, while vegans had a 30% higher risk of fracture, likely due to much lower calcium intakes (13).To ensure adequate calcium intakes, vegetarians, and in particular those following a vegan diet, are recommended to include dietary sources of calcium such as fortified plant-based milks, tofu and low oxalate greens (14, 69). If adequate intakes are not achieved, supplementation should be considered at doses <500mg for maximum absorption (1).

While an unbalanced vegetarian diet has the risk for nutrient deficiency, the benefits of following a well-balanced vegetarian diet are well researched and evident. It has been found that overall, vegetarians tend to be slimmer, appear to be in better health with a reduced risk of chronic disease and greater longevity when compared to omnivores (76) (85). The

reasoning behind improved health outcomes are less clear, but may be due to decreased meat consumption, increased consumption of particular foods (77), the pattern of foods eaten, or other healthy lifestyle components often related to vegetarianism (76, 86).

2.4 Conclusion

Calcium is an essential mineral that is only available through dietary sources and mainly found in milk and milk products. Adolescence is a period where substantial bone growth occurs and inadequate intakes of calcium during this time have a direct relationship to the development of osteoporosis, a life-limiting disease that is increasing, particularly in Western countries. Data regarding calcium intakes of New Zealanders is now 10 years old but did identify that the majority of adolescent females did not meet the EAR for calcium. A high prevalence of inadequate intakes has also been observed in other Western countries, however, the changes in dietary patterns and food choices contributing to poor intakes is not clear.

3. Objective Statement

The calcium intake of New Zealand adolescent females has not been closely examined in the past ten years. The primary aim of this thesis is to describe the current dietary calcium intake of New Zealand adolescent females aged 15-18 years.

Specific objectives of the present study are to:

1. Assess the usual dietary intake of calcium and determine the prevalence of inadequate dietary calcium intake of adolescent females aged 15-18 years in New Zealand.
2. Describe the most common dietary sources of calcium for adolescent females aged 15-18 years in New Zealand.
3. Compare the dietary calcium intakes and major food sources of vegetarian and omnivore adolescent females.

4. Methods

4.1 Study Design

Data for this cross-sectional observational study was collected from eight locations throughout New Zealand; Dunedin, Wellington, Christchurch, New Plymouth, Nelson, Whangarei, Tauranga and Wanaka. Data collection took place in two waves between February and April 2019 and July and August 2019. Ethical approval was provided by the University of Otago Human Ethics Committee (reference H19/004) (Appendix A & B) and the study was registered with the Australian New Zealand Clinical Trials Registry: ACTRN12619000290190.

4.2 Participant Recruitment

Females from eight locations throughout New Zealand and who were aged between 15-18 years were recruited into the study. The inclusion criteria for participation was as follows: individuals who self-identified as female, were aged 15 - 18 years, spoke and understood English. Participants were excluded if they were pregnant. Two methods of recruitment were used; school-based and targeted recruitment.

School-based recruitment: schools in locations convenient to data collectors, had a sufficient female roll and were from a range of deciles were identified. The principal investigators (PI) and the SuNDiAL coordinator contacted suitable schools in November 2018 inviting the school to participate. Schools which did not respond to the email within two weeks, were followed-up by phone. Seven schools were recruited via the initial email and phone contact and the remaining six schools were recruited via word of mouth. Data collectors visited the recruited schools at the beginning of each data collection phase and gave a power-point presentation that outlined the SuNDiAL project and the requirements

of participating in the study. Students who expressed interest were asked to either provide their name, age, and email address after the presentation, or visit the study website to receive information of the study requirements in greater detail. Those interested in participating were able to provide their contact details and receive a link to the online consent and enrolment. Participants who were under the age of 16 years were required to provide an email address of a parent/guardian, who was then contacted via email and asked to provide online consent for their daughter to participate in the study. Participants were free to contact data collectors via phone or email to ask questions about the study.

Targeted Recruitment: Following low recruitment of participants who identified as vegetarian in wave one (n=9), a decision was made to specifically target vegetarian female adolescents in Dunedin, regardless of their secondary school. Advertising for the vegetarian arm of the SuNDiAL study was placed in local papers and social media in Dunedin. Information and consent procedures were the same as described above in the school-based recruitment.

4.3 Data Collection

Data collection involved three stages; enrolment and self-administered dietary habits questionnaires, school visits (24-hr recall, anthropometric, accelerometer and biochemical data collection), and a phone interview to obtain a second 24-hr dietary recall.

Once participants had completed the online consent and answered initial demographic, vegetarianism, and health questions they were asked to complete the rest of the online questionnaires. These questionnaires assessed dietary habits, attitudes and motivations for food choice, as well as weight-loss intentions and methods.

Data collectors contacted participants by phone or email to schedule a visit during school hours for school-based recruitment, or after school, for respondents to the targeted recruitment. The visit was expected to take approximately an hour per participant and data collectors followed a daily data collection procedure (Appendix E), collecting a 24-hr dietary recall and anthropometric data, described in **Figure 4.1.**

Anthropometric data	Measuring tool	Method
Height:	Stadiometer (Seca 213: and Wedderburn)	Data collectors measured height in duplicate. If measurements were more than 0.5 units out, a third measurement was performed.
Weight:	Scales (one of Medisana PS420; Salter 9037 BK3R; Seca Alpha 770; or Soehnle Style Sense Comfort 400)	Data collectors recorded weight in duplicate. If measurements were more than 0.5 units out, a third weight was recorded.

Figure 4.1. Anthropometric Data

A second 24-hr dietary recall was carried out over the phone or by video-call and took approximately 30 minutes per participant. In order to capture variation in participants dietary intake between days, data collectors were asked to collect one week-day recall and one weekend-day recall from participants.

4.4 Measurement Tools

4.4.1 Enrolment and dietary habits questionnaire

Information regarding demographics, vegetarianism, health status and dietary habits was collected using an online questionnaire (Appendix G & H). Questionnaires were adapted from previous validated questionnaires (87-91) and, where necessary, modified to make them suitable for New Zealand adolescents. Questionnaires were administered in REDCap, an online survey platform. The Dietary Habits Questionnaire (Appendix H) was based on

the qualitative FFQ used in the 2008/09 New Zealand Adult Nutrition Survey (6). Dietary habits data used in this thesis included responses to questions regarding the type and frequency of milk and sugar sweetened beverages consumption. Consumption frequency responses were coded as rare (never or rarely), irregular (monthly or 2-3 times per month), regular (once a week, 2-4 times per week or 5-6 times per week) and daily (once or more per day).

Ethnicity was derived by asking participants to report their affiliation with nine different ethnic groups (New Zealand European, Maori, Samoan, Cook Island Maori, Tongan, Niuean, Chinese, Indian, Other). Each participant's ethnicity was then determined using a standard, consistent order with Māori and then Pacific being prioritised.

NZdep2013 is an area-based index of socioeconomic deprivation based on a combination of the following 2013 census variables: income, benefit receipt, transport (access to car), household crowding, home ownership, employment status, qualifications, support (sole-parent families) and access to a telephone (92). Participants were assigned to a mesh-block based on their home address and the corresponding NZdep2013 score of 1-10 determined. A value of 10 indicates residence within an area of the highest deprivation in New Zealand (92).

4.4.2 24-hour dietary recalls

Dietary intake was estimated for participants using two multiple pass 24-hr diet recalls. Each 24-hour recall required participants to recall everything consumed (food and beverages) from midnight to midnight the previous day. Data collectors prompted participants to recall details such as brands, and enhanced estimations of quantities

consumed using household measures, food models and photographs of different portion sizes (Appendix D & F). Recalls were entered into FoodWorks9 (Xyris Software Australia Pty Ltd) by data collectors in order to calculate the energy, macronutrient and micronutrient content of the diet. FoodWorks9 uses the New Zealand food composition tables FOODfiles 2018 (The New Zealand Institute for Plant and Food Research Limited) with additional ANS 08/09 recipes.

4.4.3 Anthropometry

Weight and height were measured in duplicate by the data collectors who were trained in the standardised study protocols, (Appendix C). Briefly, height was measured using a stadiometer and weight was measured using scales that had been calibrated by the research team (Figure 4.1). All measurements were taken in duplicate and rounded to the nearest 0.1 cm or 0.1 kg respectively. If the difference in the two measurements was greater than 0.5 units, a third measurement was taken. The average of the two measurements were used to calculate body mass index (BMI) and converted to BMI z-scores were calculated using the WHO growth charts (93). Participants were classified into BMI z-score sub-groups for comparisons of calcium intake and prevalence of inadequate intakes. These sub-groups were; 'healthy' BMI z-score >-2 to <1 and 'overweight and obese' BMI z-score >1 to >2.

4.5 Data Monitoring and Quality Control

Data collection was the responsibility of final year Master of Dietetics students under the supervision and direction of the PIs. All data collectors completed a 6-week research methods paper led by the PIs, designed to focus on preparing for the project. A further 2-week intensive training in dietary data collection and processing occurred immediately prior

to data collection. Standard operating procedures for anthropometry, 24-hr dietary recall and data entry into FoodWorks were used to ensure consistency between data collectors.

An inter-rater reliability study was carried out during the training period to demonstrate consistency in anthropometric measurements between data-collectors. Twenty-seven of the 30 data collectors took part in the assessment and a convenience sample of 12 girls between the ages of 15 and 18 gave consent to have their height, weight and ulna length measured. Data collectors measured four girls twice. Repeats were not successive, and data was recorded on a new page for each repeat. A standard protocol was given to all data collectors and measurements were not to be read out loud. Inter-rater reliability was assessed using mixed effects intra-class correlation coefficients (ICC).

The ICC for weight was 1.00; the ICC for height was 0.92; which indicated agreement between data collectors. Variation in measures for height were greatest when measuring the tallest girls, suggesting that more care was needed when measuring taller girls. In response to this, a step stool was provided to all data collectors along with safety instructions.

REDcap (research electronic data capture), a secure web application used to build and manage online surveys and databases, was used where possible to minimize the need for extensive data entry and cleaning. Checks of each REDcap variable were carried out before statistical analysis took place.

4.6 Statistical Analysis

Estimates of ‘usual intake’ were calculated from the two 24-hr diet recalls using the multiple source method (MSM) software programme (94) which adjusts for within person variation

of calcium intakes. The total amount of calcium from each of 33 food groups was calculated for each participant. The ten food groups with the highest median intakes (or the 75th percentile if medians were equal) for the whole group were identified. The proportion of total calcium provided by each of the 33 food groups for all participants was also calculated. Mean and 95% confidence intervals of these proportions were calculated for the whole group.

Statistical analyses during data cleaning and preparation was carried out using Stata (StataCorp. 2017. *Stata Statistical Software: Release 15*. College Station, TX:StataCorp LLC). School clusters were accounted for in all analyses using appropriate methodology. Excel (version, Microsoft) was used to determine estimates of means, medians and prevalence and were reported with either ± standard deviation (SD) or 95% confidence intervals.

The difference of the mean (95% CI) was calculated to detect any differences in calcium intake between participants residing in high levels of deprivation compared to participants residing in moderate and low levels of deprivation. It was also used to calculate any difference in calcium intake between participants classified as healthy compared to participants classified as overweight and obese. All data management and statistical analysis was overseen by the study biostatistician, Dr Jill Haszard (PI).

5. Results

Expressions of interest were provided by 495 adolescent females of which 282 (56.7%) consented to participate (**Figure 5.1**). During wave 1 of data collection, 145 participants were recruited, nine of which self-reported as vegetarian. During wave 2, 137 participants were recruited with 27 reporting as vegetarian (Figure 5.1). Approximately one quarter (28%) of the 36 vegetarians, self-identified as vegan **(Table 5.1)**. Of the 274 participants analysed, 26 participants did not complete anthropometric measurements, 23 participants did not complete dietary recalls and 26 participants did not complete the dietary habits questionnaire.

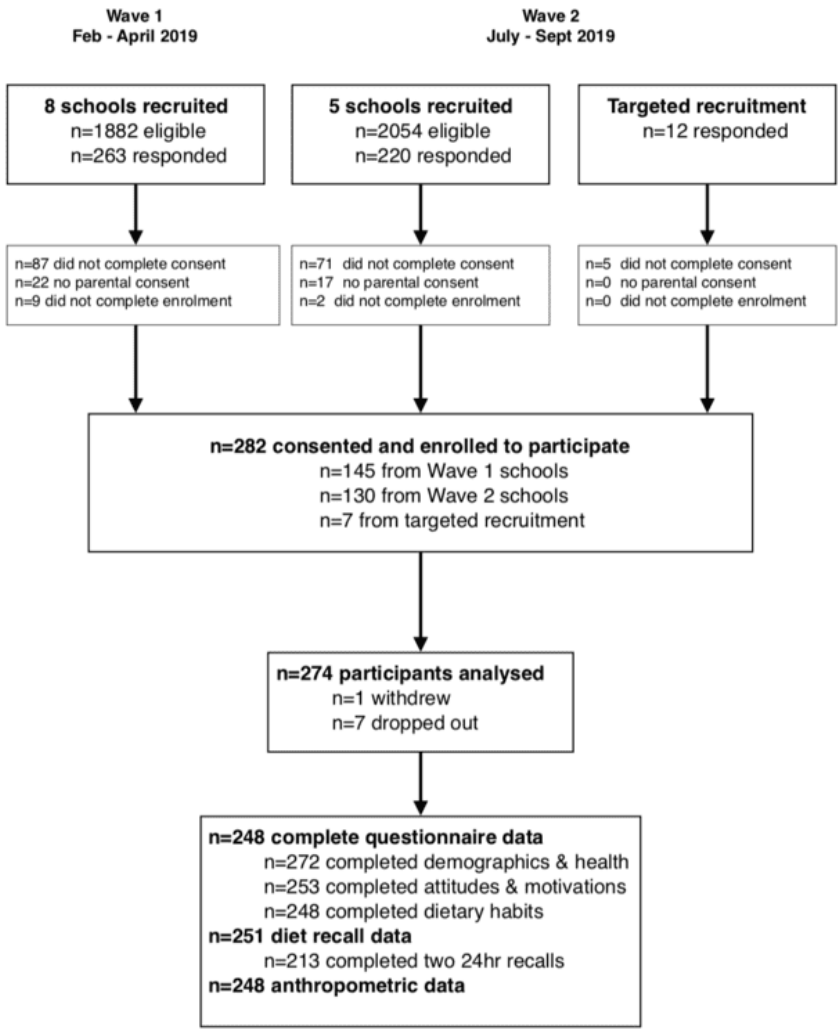

Figure 5.1 Participant recruitment

5.1 Demographics and Anthropometry

The mean (± SD) age of all participants was 16.8 (± 0.8) years. The majority of participants identified as NZ European (79.1%) and were categorized as residing in areas of low or moderate deprivation (82.4%) (Table 5.1). More than half (58%) of participants were categorized as having a healthy weight, while one fifth (20.7%) were classified as overweight and a further 9.3% as obese.

Table 5.1 Demographic and health characteristics of New Zealand adolescent females

Characteristics	n	(%)
All	279	
Age, (years)		
15-16	153	(54.8)
17-18	126	(45.2)
Ethnicity	278	
NZEO	220	(79.1)
Maori	43	(15.5)
Asian	9	(3.2)
Pacific	6	(2.2)
BMI category (BMI z-score)	247	
Underweight <-2	0.0	(0)
Healthy >-2 and <1	163	(66.0)
Overweight >1 and <2	58	(23.5)
Obese >2	26	(10.5)
Deprivation Level[1]	278	
Low	102	(36.7)
Moderate	127	(45.7)
High	49	(17.6)
Diet Status[2]	279	
Omnivore	243	(87.1)
Vegetarian	26	(9.3)
Vegan	10	(3.6)
Supplementation[3]		
All	92	(33.0)
Calcium containing	9	(3.2)

[1] Deprivation Level 'low' NZDep2013 1-3, 'moderate' NZDep2013 4-7, 'high' NZDep2013 8-10

[2] Diet status self-idetified

[3] Supplementation self-recorded

BMI, body mass index; NZEO, New Zealand European and other

5.2 Dietary calcium intake

Almost all (98%) of the first 24-hr diet recalls were conducted on a week-day, whereas, more than one third (40%) of repeat 24-hr diet recalls were conducted on a weekend day (**Table 5.2)**.

Table 5.2 Days of the week for 24-hr diet recall collection

	First diet recall		**Second diet recall**	
Days of week	n	(%)	n	(%)
Total recalls	250		217	
Monday	33	(13.2)	60	(27.7)
Tuesday	56	(22.4)	22	(10.1)
Wednesday	67	(26.8)	17	(7.8)
Thursday	62	(24.8)	16	(7.4)
Friday	27	(10.8)	15	(6.9)
Saturday	-	-	27	(12.4)
Sunday	5	(2.0)	60	(27.7)

The usual calcium intakes of both the overall study population and demographic and anthropometrical subgroups are shown in **Table 5.3**. The median (IQR) usual intake of dietary calcium was 711 (544, 925) mg/day and ranged from 287 mg/day to 1898 mg/day. There was a high prevalence of inadequate calcium intakes, with 211 (84%) participants having a dietary calcium intake below the EAR (1050 mg/day) for adolescent females (Table 5.3).

Median dietary calcium intakes were lowest in Māori participants and highest in Pacifica participants (Table 5.3). Interestingly, Māori participants had lower calcium intakes than Asian participants, despite having higher energy intakes. The higher calcium intakes in the Pacifica subgroup may be related to them having energy intakes 943 - 2184 kJ higher than other ethnic groups (Table 5.3). Furthermore, these results may also have been influenced by the low number of participants who identified as Pacifica (6 participants).

Usual calcium intakes were inversely related to levels of deprivation, with those residing in areas of high deprivation having the lowest mean calcium intakes when compared to those in both moderate and low deprivation areas (difference of the means; 104 (95 % CI: 12, 196) and 149 (95 % CI: 54, 244) mg/day respectively). There was also a higher prevalence of inadequate calcium intakes in higher deprivation areas, however, as noted above, more than three quarters of all participants had inadequate calcium intakes, regardless of deprivation level. There was no apparent difference in usual calcium intakes or the prevalence of inadequacy for participants in each body weight category (difference of the means; 55 (95 % CI: -18, 128) mg/day). This is despite lower energy intakes of participants who were classified as being overweight and obese (difference of the means; 361 (95% CI: -105, 827) kJ/day).

5.2.1 Comparison of calcium intakes of omnivorous and vegetarian participants

The usual dietary calcium intakes of 31 vegetarians compared to 219 omnivores are also shown in Table 5.3. None of the Pacific or Asian participants identified as vegetarian. The median (IQR) usual calcium intake of vegetarian participants was 764 (603, 847) mg/day, compared to 711 (534, 966) mg/day of omnivores. Almost all (94%) vegetarian participants had calcium intakes below the EAR for calcium (1050mg/day), however, omnivores also had a high prevalence of inadequate intakes (83%).

Across other participant characteristic subgroups, vegetarian participants had a slightly higher prevalence of inadequate calcium intakes when compared to omnivore participants (Table 5.3). All but two of the vegetarian participants had inadequate calcium intakes and any differences seen within the vegetarian subgroups of ethnicity, deprivation and body weight, reflect the characteristics of these participants.

Table 5.3 Usual daily energy and calcium intake and prevalence of inadequate calcium intake of vegetarian and omnivore New Zealand adolescent females

	Total Sample				Omnivores				Vegetarian			
Participant characteristics	n	Median usual energy intake kJ/day (IQR)	Median usual calcium intake mg/day (IQR)	Inadequate intake[1] n (%)	n	Median usual calcium intake mg/day (IQR)	Inadequate intake[1] n (%)		n	Median usual calcium intake mg/day (IQR)	Inadequate intake[1] n (%)	
All participants	251	7943 (6805,8999)	711 (544, 925)	211 (84)	219	711 (534, 966)	181	(83)	31	764 (603, 847)	29	(94)
Age												
15-16	132	8136 (6763, 9226)	727 (539, 989)	108 (82)	120	714 (528, 989)	98	(82)	12	807 (586, 969)	10	(83)
17-18	118	7768 (6874, 8873)	710 (553, 897)	102 (86)	99	710 (535, 924)	83	(84)	19	668 (642, 838)	19	(100)
Ethnicity												
NZEO	195	8122 (6840,9047)	739 (572, 933)	163 (84)	171	736 (554, 990)	140	(82)	24	766 (645, 843))	23	(96)
Maori	39	7588 (6706, 8416)	585 (506, 906)	35 (90)	32	576 (487, 896)	29	(91)	7	655 (570, 906)	6	(86)
Pacific	6	9065 (7703, 12128)	831 (710, 1161)	4 (67)	6	831 (710, 1161)	4	(67)	-		-	
Asian	9	6881 (6638, 8666)	647 (324, 839)	7 (78)	9	647 (324, 839)	7	(78)	-		-	
Deprivation Level[2]												
Low	92	8126 (6961, 9031)	755 (585, 1032)	72 (78)	80	788 (585,1051)	60	(75)	12	651 (586, 781)	12	(100)
Moderate	115	7987 (6706, 9053)	717 (540, 912)	98 (85)	100	710 (529, 913)	85	(85)	15	838 (708, 906)	13	(87)
High	43	7670 (6441, 8878)	607 (489, 796)	40 (93)	39	607 (489, 796)	36	(92)	4	615 (509, 755)	4	(100)
Body Weight[3]												
Healthy	163	8162 (6840, 9182)	723 (572, 966)	135 (83)	139	723 (554, 1000)	113	(81)	24	736 (645, 838)	22	(92)
Overweight & Obese	84	7755 (6790, 8672)	694 (527, 872)	73 (87)	77	690 (526, 878)	66	(90)	7	792 (565, 858)	7	(100)

[1] Inadequate intake defined as calcium intakes less than the EAR for New Zealand females aged 14 – 18 years of 1050 mg/day
[2] Deprivation level defined as 'low' NZDep2013 1-3, 'moderate' NZDep2013 4-7, 'high' NZDep2013 8-10
[3] Body Weight categories defined as 'healthy' BMI z-score>-2 <1, 'overweight and obese' BMI z-score >1 >2;
EAR, estimated average requirement; IQR, interquartile ratio (25th and 75th percentile); NZDep2013 New Zealand deprivation index 2013; NZEO, New Zealand European or other; zbmi, z- body mass index score

5.3 Food sources of dietary calcium

The percentage of contribution from each of the top nine food groups to total calcium intake are shown in **Table 5.4**. Combined, these nine food groups contributed almost three quarters (74%) of the total dietary calcium intake of all participants. Sixteen of the remaining 24 food groups not shown in Table 5.4 contributed less than one quarter (22%) of total calcium intake (Appendix I).

Milk, which included both cow and plant-based milks, was the largest source of dietary calcium. It was consumed by 236 (94%) participants and contributed 17.4 (95 % CI: 15, 19.7) % of total calcium intakes, however, the percentage contribution varied greatly among participants (0% - 79%). Cheese was the second largest contributing food group (13.0 (95 % CI: 10.6, 15.3) %), while other dairy products (cream, sour cream, yoghurt, ice-cream and dairy based dips) contributed only 5.2 (95 % CI: 4.0, 6.0) %. Other major contributors to calcium intake were bread, bread-based dishes (pizza, sandwiches) and non-alcoholic beverages which each contributed approximately 8% of total calcium.

5.3.1 Comparison of dietary calcium food sources for omnivorous and vegetarian participants

The percentage contribution of food groups to dietary calcium intakes for omnivores compared to vegetarians was generally similar (Table 5.4). Eight of the top nine food groups had only one to three percent difference in contribution between omnivores and vegetarians. The vegetable group, which includes legumes and pulses, contributed a greater proportion to calcium intake for vegetarian participants compared to omnivores (13.3 (95 % CI: 8.1, 18.6) vs 6.5 (95 % CI: 5.3, 7.8) %).

Table 5.4 Percentage of contribution of food groups to dietary calcium intake for New Zealand adolescent females

	Total Sample (n = 252)		**Omnivores** (n = 219)		**Vegetarian** (n = 31)		**Difference between Omnivore & Vegetarian**	
Food Group	Mean %[1]	(95% CI)	Mean %[1]	(95% CI)	Mean %[1]	(95% CI)	Mean %	(95% CI)
Milk	17.4	(15.0, 19.7)	17.0	(14.5, 19.4)	19.5	(11.8, 27.3)	+2.5	(-5.3, 10.3)
Cheese	13.0	(10.6, 15.3)	13.3	(10.8, 15.9)	11.2	(4.2, 18.2)	-2.1	(-5.0, 9.2)
Non-Alcoholic Beverages	8.0	(7.1, 9.0)	8.1	(7.0, 9.2)	7.5	(5.7, 9.3)	-0.6	(-1.4, 2.6)
Bread based dishes	7.8	(5.8, 9.7)	7.9	(5.8, 10.0)	6.9	(1.4, 12.3)	-1.0	(-1.0, 3.0)
Bread	7.7	(6.7, 8.8)	7.6	(6.5, 8.7)	8.0	(5.4, 10.5)	+0.4	(-2.3, 3.1)
Vegetables	7.4	(6.1, 8.7)	6.5	(5.3, 7.8)	13.3	(8.1, 18.6)	+6.8	(1.6, 12.0)
Grains and Pasta	5.2	(4.0, 6.0)	5.0	(3.7, 6.2)	6.3	(3.3, 9.2)	+1.3	(-1.9, 4.5)
Dairy Products	5.2	(4.0, 6.3)	5.6	(4.2, 7.0)	2.4	(0.7, 4.1)	-3.2	(0.9, 5.5)
Fruit	3.0	(2.5, 3.6)	3	(2.4, 3.5)	3.7	(2.1, 5.2)	+0.7	(-0.9, 2.3)

[1]Mean percentage contribution to calcium intake

CI, confidence interval

5.4 Calcium supplements

Of 251 participants, 92 reported nutritional supplement use (37%). Of these, 12% (11 participants) reported taking a supplement likely to contain calcium. Examples of these were multivitamins, protein powder, calcium citrate, or chaste tree. While brand data was available for all reported calcium containing supplements, frequency of consumption was not consistent with participants ranging from daily to not very often. In addition, dosage of nutritional supplements was not declared by participants. This lack of information made supplemental calcium intake difficult to quantify accurately. Consequently, due to a small proportion, (4%), of the total sample population obtaining supplemental calcium, contribution of nutritional supplements to total calcium intake was not considered in this thesis.

5.5 Dietary habits

The food group consumption patterns among New Zealand adolescent females for milk and sweetened beverages are shown in **Table 5.5**. Milk contributed the largest amount of calcium to both vegetarian and omnivorous diets. Participants that consumed milk rarely or irregularly had the lowest median calcium intakes with a difference of 193 mg/day, or approximately 169mls of full fat cow's milk. Similar patterns are seen among each of the omnivore and vegetarian subgroups, however, omnivores consuming milk daily had 73 mg/day more calcium than vegetarian participants consuming milk daily.

Conversely, detecting a pattern between the consumption of sweetened beverages and median calcium intakes among participants is more challenging. Those who consumed sweetened beverages daily had the highest median (IQR) calcium intake (1064 (711, 1241)

mg/day) although there was still a range of intakes in this group (526 mg/day to 1351 mg/day). These results may be influenced by the small number of participants who consumed sweetened beverages daily (n=7). Of note, fruit juice was consumed daily by four of these seven participants who all had calcium intakes greater than the EAR (data not shown). Furthermore, an inverse pattern was seen between those who consumed sweetened beverages rarely, irregularly and regularly. Those who rarely consumed sweetened beverages had the next highest median (IQR) calcium intake 744 (601, 979) mg/day, while those who consumed sweetened beverages regularly had the lowest calcium intake 706 (553, 912) mg/day. Similar patterns occur in both omnivorous and vegetarian participant groups, however, the decrease in calcium intake was not substantial enough to draw any clear conclusions. The small sample size of vegetarians (n=29) must be considered as no vegetarians consumed sweetened beverages daily.

Table 5.5 Usual daily calcium intake determined by milk and sweetened-beverage consumption patterns of 227 New Zealand adolescent females

Food Groups	Total Sample				Omnivores				Vegetarian			
	n	(%)	median mg/day	(IQR)	n	(%)	median mg/day	(IQR)	n	(%)	median mg/day	(IQR)
Milk	227				197				30			
Rarely[1]	33	(14.5)	663	(522, 711)	28	(14.2)	588	(446,711)	5	(14.7)	708	(668, 764)
Irregularly[2]	7	(3.1)	647	(398, 667)	5	(2.5)	647	(607, 660)	2	(5.8)	533	(398, 667)
Regularly[3]	101	(44.5)	723	(570, 897)	85	(43.2)	718	(562, 897)	16	(53.3)	780	(572, 872)
Daily[4]	86	(37.9)	856	(603, 1025)	79	(40.1)	871	(582, 1033)	7	(23.3)	798	(647, 865)
Sweetened Beverages[5]	225				196				29			
Rarely[1]	52	(23.1	744	(601, 979)	45	(23.0)	743	(595, 1049)	7	(24.1)	792	(655, 847)
Irregularly[2]	91	(40.4	709	(544, 913)	76	(38.8)	701	(535, 945)	15	(51.7)	764	(597, 838)
Regularly[3]	75	(33.3)	706	(553, 912)	68	(34.7)	733	(542, 928)	7	(24.1)	663	(574, 858)
Daily[4]	7	(3.1)	1064	(711, 1241)	7	(3.6)	1064	(711, 1241)	0	(0)	-	-

[1]consumption response of never or rarely
[2]consumption response of monthly or 2-3 times per month
[3]consumption response of once a week, 2-4 times per week or 5-6 times per week
[4]consumption response of once per day or more than once per day
[5]sweetened beverages include diet, fizzy, juice and energy beverages, classified by highest consumption response
CI, confidence interval

5.5.1 Sub-categories of milk type

Different types of milks that were consumed by participants are shown in **Table 5.6**. Three quarters of all participants reported drinking cow's milk (74.6%) with the remainder choosing plant-based milk. Cow's milk was the more popular type of milk among omnivores, chosen by 81% of these participants, whereas, plant-based milk was consumed more commonly by vegetarian participants (67.7%). Standard or whole fat milk was the predominant type of both cow and plant-based milks.

Table 5.6 Sub-categories of milk type among New Zealand adolescent females

	Total Sample		**Omnivores**		**Vegetarian**	
Categories	n	(%)	n	(%)	n	(%)
Milk Type	236		205		31	
None	1	(0.4)	1	(0.5)	-	-
Cow's Milk	176	(74.6)	166	(81.0)	10	(32.3)
Plant-Based	59	(25.0)	38	(18.5)	21	(67.7)
Cow Milk Type	170		160[1]		10	
Standard	99	(58.2)	91	(56.9)	8	(80.0)
Reduced Fat	44	(25.9)	43	(26.9)	1	(0.1)
Skim/Trim	17	(10.0)	16	(10.0)	1	(0.1)
Other	10	(5.9)	10	(6.3)	-	-
Plant-based Milk Type	57		38		19[2]	
Regular	45	(76.3)	28	(73.7)	17	(81.0)
Lite	11	(18.6)	9	(23.7)	2	(9.0)
Sweetened/Flavoured	1	(1.7)	1	(2.6)	-	-

[1] Data missing for 6 participants
[2] Data missing for two participants

6. Discussion and Conclusion

This study examined the calcium intakes of omnivore and vegetarian female adolescents from 13 secondary-schools in New Zealand. The usual calcium intakes of all participants was 711 mg/day with no difference found between omnivorous and vegetarian participants (711 mg/day vs 764 mg/day). Inadequate calcium intakes were common, with more than three quarters of participants (84%) having intakes below the EAR. Vegetarian participants had a higher prevalence of inadequate intakes compared to omnivorous participants although inadequacy was very common in both groups (97% vs 83%, respectively). The contribution of calcium from food groups were similar for both omnivore and vegetarian participants, however the consumption of cow's milk was more common among omnivore participants and plant-based milk was more common among vegetarians.

6.1 Calcium Intake

In the present study, a large proportion of adolescent females had calcium intakes below the estimated average requirement of 1050 mg/day. The usual calcium intakes of New Zealand adolescent females in the present study (711 mg/day) were similar to those observed in previous literature. The median calcium intake for adolescent females in the ANS 08/09 was 682mg/day (6) with 88% of adolescent females aged 15-18 years having inadequate calcium intakes (6). Furthermore, a recent systematic review that examined calcium intakes from a number of countries showed that mean calcium intakes were higher in New Zealand compared to Southeast Asia, North Africa and South America (<400-600mg/day), but lower mean intakes than Northern European countries (>1000mg/day) (39). While this review focused on males and females over 15 years, it showed that New Zealand

adults are also not achieving the EAR for calcium. This indicates that the low intakes observed during adolescence may be carried through into adulthood (95, 96).

The high prevalence of inadequate calcium intakes puts adolescent New Zealand females at risk of developing osteoporosis as they age. Osteoporosis occurs because inadequate calcium intakes in adolescence contribute to lower bone mass (97-99) and increased bone thinning (100) (101). Together, being both female and consuming inadequate calcium puts adolescent females at higher risk of developing osteoporosis. Furthermore, consequences of the low calcium intakes observed in the current study may be made worse by known inhibitors of calcium absorption (5). It would be beneficial to investigate possible associations between calcium intake and inhibitory factors such as caffeine, phytates, salt and protein.

An inverse relationship between calcium intake and deprivation level was indicated. However, the difference in intakes of those residing in high deprivation areas vs low deprivation areas was not substantial, equating to half a glass (125 mL) of milk (148 mg calcium). This concurs with the findings of the ANS 08/09 which suggested no difference in calcium intakes among adolescent females residing in different deprivation levels after age, sex and ethnicity were adjusted for (6).

Energy intakes of participants who were categorized as being overweight and obese were lower than the energy intakes of participants who were categorized as having a healthy body weight. This may be due to under-reporting and/or intentionally restricting calorie intake to decrease energy intakes to facilitate weight loss (102, 103) Consequently, the usual calcium intake was marginally lower (27 mg/day) for the overweight and obese group compared to

the healthy weight group. A previous study by Packard et al. suggested adolescent females may consider dairy products fattening and therefore may refuse or limit the intake of calcium rich foods such as milk and cheese (45).

6.2 Food sources of calcium

Milk (including flavoured milk), cheese and non-alcoholic beverages were the three food groups that contributed the most calcium to participants' diets. Calcium is not widely spread throughout non-dairy food groups and these findings are comparable to previous research that has investigated the food sources of calcium (1, 42). In the present study, milk made the largest contribution (17.4%) to female adolescent calcium intakes, similar to the contribution of milk to calcium intakes in the ANS 08/09 (19%) (6). This contribution of milk to calcium intakes was also reflected by the milk consumption patterns of SuNDiAL participants. Those who drank milk daily had higher calcium intakes (856 mg/day) compared to those who drank milk irregularly (647 mg/day) and rarely (663 mg/day). Previous studies conducted in Australia and the United States have shown that a decline in mean calcium intakes throughout adolescent years was related to reduced milk consumption (40-42). Similarly, the ANS 08/09 found that female adolescents consumed the least amount of milk when compared to other age groups (6). Reasons for this are unclear, but may be due to evolving dietary patterns, misconceptions about milk being linked to weight gain and a general lack of knowledge about milk being a good source of calcium (45, 66). The present study did not assess why participants excluded milk, but given it is a key food for ensuring adequate intakes of calcium, further research regarding barriers to milk consumption and strategies for overcoming these is warranted.

Further analysis of the patterns of beverage consumption and their influence on calcium intakes is also warranted. Daily consumers of fruit juice in the current study had higher usual calcium intakes, however, the small numbers (n=4) does not allow any firm conclusions to be drawn. Fruit juice can be voluntarily fortified in New Zealand (104) and may be a means of increasing calcium intakes in this population group.

6.3 Dietary calcium intakes of vegetarian vs omnivore diets

Vegetarianism is becoming increasingly popular as consumers aim to reduce the environmental impact of their food choices and decrease their risk of developing non-communicable diseases (53). The risk of nutritional inadequacy for more restrictive variants of vegetarian diets, such as veganism, is of concern. Despite studies that vegetarian diets may lead to a greater prevalence of inadequate intakes (7), no substantial differences in usual calcium intakes were found between omnivore and vegetarian participants in the current study. This could be attributed to vegetarians being more health conscious and aware of their nutritional needs (76) but may also be due to the main food source of calcium (dairy products) being included in many vegetarian diets (11, 12, 82). More restrictive diets such as those followed by vegans do require the exclusion of dairy products and, therefore, warrant more detailed investigation of both dietary calcium intakes and calcium food sources (69).

Although milk was a major source of calcium for both vegetarians and omnivores, the type of milk consumed differed between groups. The majority of omnivores consumed cow's milk, while two thirds of vegetarian participants consumed plant-based options. The calcium content of plant-based milks can differ depending on the level of calcium fortification, and ranges widely from 0 – 206 mg per 100 mls (105). Plant-based milks

consumed by SuNDiAL participants were matched to calcium fortified products in Foodworks although detail regarding the fortification status of plant-based milks consumed by participants was not recorded. This variation, as well as unaccounted for differences in calcium bioavailability between plant-based and cow's milk (106), may have overestimated the calcium content of vegetarian intakes, thus causing an even greater risk of inadequate calcium intakes in vegetarian participants. This highlights the need to ensure that accurate data regarding the nutrient composition of food items, including the level of fortification is available.

6.4 Strengths and limitations

A major strength of this study was that trained Masters of Dietetics students conducted 24-hr recalls, anthropometric measurement and data entry. Dietetic students undertook training based on standardized data collection protocols to ensure consistency between data collectors. All dietary data entries were checked and verified by academics experienced in large scale dietary surveys and repeat 24-hour dietary recalls were collected for the majority of participants, thus allowing for the adjustments for usual intake to be made.

There were some limitations to the study. The exclusion of calcium supplement data, due to insufficient calcium content and dosage details, means that calcium intakes may have been underestimated. It is unlikely, however, that the small amount of additional calcium provided by multivitamin supplements (10mg to 87mg) would have been sufficient to achieve the EAR (1). In contrast, calcium intakes from plant-based milks may have been overestimated due to limited variants of these products being available in the FoodWorks database. The small number of participants who identified as vegetarian prevents clear conclusions regarding the differences in calcium intakes and food sources between

omnivore and vegetarian diets to be identified. Future research in a larger vegetarian population would help to determine if the findings of this study are a true representation of differences.

6.5 Conclusion

Examining the usual calcium intakes of adolescent females in New Zealand has shown that a substantial proportion have intakes that do not meet their requirements (6, 39). These results strongly suggest that this population is at risk of developing osteoporosis in later life and highlights a need for education and interventions targeted at improving calcium intakes among adolescent females. While inadequate calcium intakes may be more prevalent in vegetarians due to the evolving versions of the diet, no difference in intakes between vegetarians and omnivores was detected. Future work should focus on quantifying the calcium content of vegetarian diets which restrict dairy products. Achieving adequate intakes would require careful food selection and knowledge about the potential consequences of inadequate calcium intakes. Furthermore, exploration of the role of commonly consumed fortified foods such as plant-based milks and fruit juice is also recommended.

7. Application of Research to Dietetic Practice

The human diet is ever-evolving with new food products and diets constantly being developed. These changes require the dietetic profession to keep up to date with the health benefits of new products and food choices. The present study confirms that New Zealand female adolescents are at risk of inadequate calcium intakes, which may play a role in the risk of osteoporosis among this population group. This study has contributed to the evidence which describes the intake and food sources of calcium for adolescent females in New Zealand and highlights some potential areas of future work including the calcium content of vegan diets and the role of calcium -fortified foods in meeting the increased calcium needs of this age-group.

It is evident that calcium is a nutrient of concern for adolescent females in New Zealand. Dietitians and other health care professionals need to be aware of this and ensure interventions are provided to prevent low dietary calcium intakes among this group. It also highlights the risk of osteoporosis as a growing public health issue (107). The high prevalence of inadequate intakes in the present study, highlights how the ageing population is at high risk of developing osteoporosis and should increase awareness of the need for interventions to be developed and implemented to improve calcium intakes for adolescent females. At the population level, this study highlights the importance of advocating for national survey data to identify where interventions, such as greater food fortification, is warranted.

This research has been a completely new process for me, from identifying extensive and relative research to recruiting participants and carrying out accurate skills such as anthropometric measurements and dietary recalls. Alongside learning the risks associated with inadequate calcium intakes for future generations I have learnt a lot about myself. Time

management has always been an area I have had to work on. This research time was different to my previous years at University which have been structured with lectures and labs to attend. While this research project had deadlines, I was challenged by structuring my own day in order to meet these deadlines. I have learnt that having lists and objectives to check off each week or even each day is an essential tool I will use to ensure I stay on track with future projects to meet deadlines. When certain tasks do not seem attainable, breaking them down into smaller, more attainable tasks is a way to keep progressing and by the end of my research I had implemented a clear and attainable schedule in order to meet guidelines for hand in.

I also have learnt the importance of identifying and understanding limitations. During the data collection, I was aware underreporting and overreporting was inevitable due to the nature of self-reporting. This was something I had been aware of in previous student clinics during my degree, however, due to this project being a nation-wide health update, I was more aware of the implications this may have on the data that was going to be published. I understand this cannot be completely eradicated; however, this also gave me an opportunity to use the skills I have acquired throughout my training and probe for more information without passing judgement or leading participants. This was a big challenge as it was easy to use leading words such as, ‘was that full fat milk’ rather than, ‘what type of milk was that’. Having resources available to guide me through this process was essential and has highlighted the importance of mastering these techniques for my future dietetic practice to try and represent the population or patients I work with as accurately as possible. This in turn will help to generate the best intervention possible.

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9. Appendices

9.1 Appendix A. Ethical approval

H19/004

Academic Services
Manager, Academic Committees, Mr Gary Witte

4 February 2019

Dr J Haszard
Department of Human Nutrition
Division of Sciences

Dear Dr Haszard,

I am writing to let you know that, at its recent meeting, the Ethics Committee considered your proposal entitled "**SuNDiAL Project 2019: Survey of Nutrition Dietary Assessment and Lifestyle Phase 1: Adolescent Females**".

As a result of that consideration, the current status of your proposal is:- **Approved**

For your future reference, the Ethics Committee's reference code for this project is:- **H19/004**.

The comments and views expressed by the Ethics Committee concerning your proposal are as follows:-

While approving the application, the Committee would be grateful if you would respond to the following:

Information Sheet

A typing error was noted on the Information Sheet, under the heading *"Is there any risk of discomfort or harm from participation?"*, line 3, "some" should read "someone".

Consent Form

Please amend the Consent Form to include an option for participants to indicate whether they would prefer for their blood samples to be disposed of using standard methods or with a Karakia.

Please provide the Committee with copies of the updated documents, if changes have been necessary.

The standard conditions of approval for all human research projects reviewed and approved by the Committee are the following:

Conduct the research project strictly in accordance with the research proposal submitted and granted ethics approval, including any amendments required to be made to the proposal by the Human Research Ethics Committee.

Inform the Human Research Ethics Committee immediately of anything which may warrant review of ethics approval of the research project, including: serious or unexpected adverse effects on participants; unforeseen events that might affect continued ethical acceptability of the project; and a written report about these matters must be submitted to the Academic Committees Office by no later than the next working day after recognition of an adverse occurrence/event. Please note that in cases of adverse events an incident report should also be made to the Health and Safety Office:

http://www.otago.ac.nz/healthandsafety/index.html

Advise the Committee in writing as soon as practicable if the research project is discontinued.

Make no change to the project as approved in its entirety by the Committee, including any wording in any document approved as part of the project, without prior written approval of the Committee for any change. If you are applying for an amendment to your approved research, please email your request to the Academic Committees Office:

gary.witte@otago.ac.nz

jo.farrondediaz@otago.ac.nz

Approval is for up to three years from the date of this letter. If this project has not been completed within three years from the date of this letter, re-approval or an extension of approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

The Human Ethics Committee (Health) asks for a Final Report to be provided upon completion of the study. The Final Report template can be found on the Human Ethics Web Page http://www.otago.ac.nz/council/committees/committees/HumanEthicsCommittees.html

Yours sincerely,

Mr Gary Witte
Manager, Academic Committees
Tel: 479 8256
Email: gary.witte@otago.ac.nz

c.c. Assoc. Prof. L Houghton Department of Human Nutrition

9.2 Appendix B. Maori Consultation

Monday, 17 December 2018

Dr Meredith Peddie
Department of Human Nutrition

Tēnā Koe Dr Meredith Peddie

The SuNDiAL Project 2019: Survey of Nutrition, Dietary Assessment and Lifestyle.

The Ngāi Tahu Research Consultation Committee (the Committee) met on Tuesday, 11 December 2018 to discuss your research proposition.

By way of introduction, this response from The Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states "Ngāi Tahu acknowledges that the consultation process outline in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago". As such, this response is not "approval" or "mandate" for the research, rather it is a mandated response from a Ngāi Tahu appointed Committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other Committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee base consultation on that defined by Justice McGechan:

"Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon; adequately informing a party about relevant information upon which the proposal is based; listening to what the others have to say with an open mind (in that there is room to be persuaded against the proposal); undertaking that task in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal."

The Committee considers the research to be of importance to Māori health.

As this study involves human participants, the Committee strongly encourages that ethnicity data be collected as part of the research project as a right to express their self-identity.

The Committee suggests researchers consider the Southern District Health Board's Tikaka Best Practice document, in particular patient engagement. The document also covers the collection, storage and disposal of blood and tissue samples. This document is available on the Southern District Health Board website. The Committee also refers researchers to Te Mana Raraunga Māori Data Audit Tool, which gives an overview of key Māori Data Sovereignty terms and principles.

We wish you every success in your research and the Committee also requests a copy of the research findings.

This letter of suggestion, recommendation and advice is current for an 18-month period from Tuesday, 11 December 2018 to 3 June 2020.

The recommendations and suggestions above are provided on your proposal submitted through the consultation website process. These recommendations and suggestions do not necessarily relate to ethical issues with the research, including methodology. Other Committees may also provide feedback in these areas.

Nāhaku noa, nā

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Kaiwhakahaere Pūtere
Senior Project Manager
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Email: claire.porima@otago.ac.nz
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9.3 Appendix C. Anthropometric Protocol

ANTHROPOMETRIC MEASUREMENTS

Gain verbal consent from the participant for each measurement and explain fully what you will do to obtain them. Before beginning, gain consent from the participant to use non-permanent pen for marking anatomical land marks.

NB: anthropometry tapes have a blank lead before measurement markings start - consider this when reading a measurement.

HEIGHT

1. Ask the participant to remove their shoes, as well as any hair ornaments or buns/braids on the top of the head.

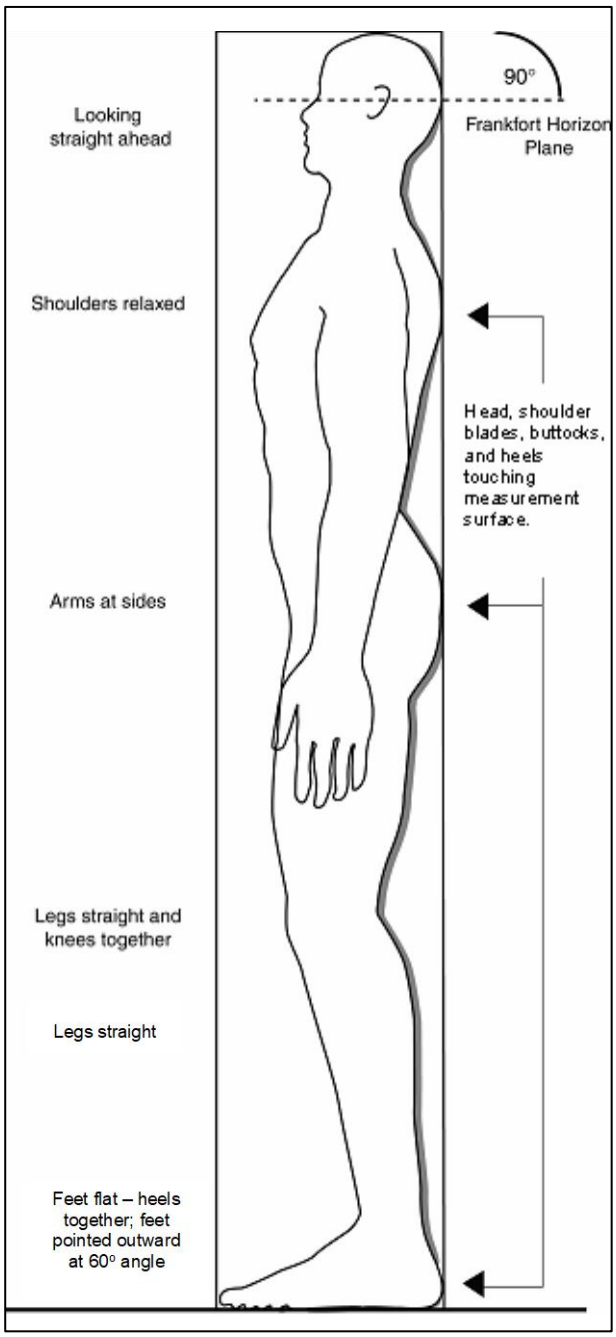
2. If the participant is taller than the investigator, use a step tool to take the measurements. Errors can be minimised by the investigator being parallel to the participant and the headpiece.

3. Tell the participant to stand with their heels together and toes apart pointing outward at approximately a 60-degree angle.

4. Make sure the back of the head, shoulder blades, buttocks, and heels of the participant are touching the backboard/stadiometer.

5. Make sure the participant's head is aligned in the Frankfort horizontal plane, where a horizontal line connects from the ear canal to the lower border of the orbit of the eye.
6. Lower the headpiece to rest firmly on the top of the participant's head and ask the participant to stand as tall as possible and take a deep breath.

7. Record the result to the nearest 0.1 cm in the HEIGHT 1 box on the recording sheet without informing the participants.



WEIGHT

1. Ask the participant to remove any heavy clothing (such as jackets, heavy tops, boots etc). As the participant would have just had their height measurement done, they should not be wearing shoes.

2. Turn on the scales, ensure they are switched on to metric (kg).

3. Ask the participant to step on to the scales so that they are facing away from the display (prevent seeing the weight) cautioning them that they need to step up onto the scales.

4. Wait for the scales to read or come to a stable number.

5. Record the participant's weight to the nearest 0.1 kg in the WEIGHT 1 box on the recording sheet without informing the participant

ULNA LENTH

Ulna length is measured between the point of the elbow and the midpoint of the prominent bone of the wrist using an anthropometric tape. This value is then compared with a standardized height conversion chart. Participants should be dressed in light clothing with no wrist watch or other jewellery on the arm that is to be measured.

1. Measure between the point of the elbow and the midpoint of the prominent bone of the wrist (non-dominant side).

2. Read and accurately record the measurement to the nearest 0.1 cm in the UNLA LENGTH 1 box on the recording sheet without informing the participants

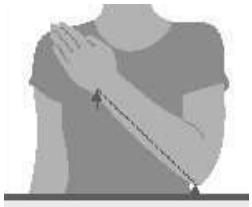


Fig 2: ulna length measurement

REPEAT ALL MEAUREMENTS

Repeat all three measurements again, in the same order, entering the measurements in the HEIGHT 2, WEIGHT 2 and ULNA LENGTH 2 box as appropriate (do no tell participant measurements).
CHECK: are any of the 1st and 2nd measurements are more than 0.5 units apart? If so take a third measurement where required.

9.4 Appendix D. 24-hr Diet Recall Protocol

24 Hour Recall

Introduce yourself to the participant, thank them for participating in the sundial project and ask them to take a seat.

"I am going to ask you about everything that you ate and drank yesterday. Please try to recall, and tell me about everything that you had to eat at drink, whether it be at home, or away from home, including snacks, drinks and water."

Stage One – Quicklist
"First, we will make a quick list of all the things you ate and drank, and then we will go back over this list and I will ask you more details about the specific foods and drinks, and the amounts."

"It might help you remember what you ate by thinking about where you were, who you were with, or what you were doing yesterday; like going to school, eating out, or watching TV. Feel free to keep these activities in mind and say them aloud if that helps."

"So starting from midnight the day before yesterday, what was the first thing you remember eating?"

Start recording quick list – keep prompting until finished

"That's great. Sometime people forget to tell us about drinks, particularly water when we do this list."

"How much water do you remember drinking yesterday?" (*record*)

"Did you have any other drinks you might have forgotten about?" (*record*)

Stage two – Collect more information
"I am now going to ask you some more specific questions about each food. We also need to work out how much of each food that you ate or drank"

"Lets start at the beginning – the first thing you remember eating was xxxx" *(record)*

What time did you eat/drink that? *(record)*

Go on to collect specific information that is relevant to each food based on the tips provided on the tip sheet. Record as much specific information as you can. Record each food item in a different row.

Use the photos and measurement aids to help the participant estimate the portion size. Remember that brand and package size will always give you the most accurate information.

Before you go onto the next food on the quick list be sure to ask if they added anything to the food they have just described.

Stage 3 – check for any further additions

"Ok, thanks for working with me to provide all of that detail. We are now going to do one more check to make sure there isn't anything else that should be on this list. I am going to read this list back to you. If you remember anything else that you ate while I am reading it back to you please interrupt me and we will record in"

Read through with the participant all the food and drink they have listed

"Is there anything you can think of that we need to add in?" (record as necessary)

"Last Question: Do you know if the salt you use at home contains iodine?" (tick appropriate box)

"Great thank you again. If it is ok with you one day in the next week I would like to ring you and go through this process again on a different day, so that we can get an idea of how the foods you eat change from day to day. What time of the day (outside of school time) would suit you for me to ring you?"

Record preferred times - remember, ideally this second 24 h recall will occur on a randomly selected day, but that might not always be possible (at the very least it should be a different day of the week than today)

Tips Sheet

Remember that the more information you can obtain about each food the more accurate the data is going to be. Please keep in mind that some of your fellow MDiet students are writing their thesis on nutrients (like Folate) that will vary from brand to brand depending on fortification so please be as careful and accurate as possible.

You need to gather more information about each food identified on the Quicklist. Below are some prompts that might help you do this.

Where possible for packaged foods collect the brand name

Potential questions to consider asking (depending on the food reported)

- What is the brand name?
- Was it fresh, canned, frozen or rehydrated?
- Was it home made? Do they know the recipe? If they do record on the recipe sheet) – this is more important for savory foods than baking (as the basic composition of a biscuit or a cake varies much less than the composition of, for example, a stir fry)
- How was it cooked? Was it baked, fried, or boiled
- Was the item coated before cooking, if so what it with flour, batter, eggs, or breadcrumbs etc?
- Was it standard, low fat, low sugar caffeine free?

Do not

- x Collect information about herbs and spices that are used in very small quantities
- x Ask leading questions
- x Ask for recipes for traditional home baking, but do note if it is gluten free.
- x Make assumptions

Do

- ✓ Keep your prompts neutral
- ✓ Ask about cooking method and the type of fat used in cooking e.g. if they say baked, ask what with?
- ✓ Collect brand names for margarine, butter, juices/fruit drinks, breakfast cereals, energy drinks, breads, dairy alternatives (e.g. almond milk) as the micronutrient content of these products can vary considerably from brand to brand.
- ✓ Ask for the recipe for less traditional home baking (e.g. brownies made with black beans, raw caramel slice etc)

Useful Prompts for Specific Food Groups

FRUIT
- Peeled or unpeeled
- Colour? – e.g. red/green apple
- Tinned? – if so was it tinned in syrup or juice, how much of the syrup/juice did they have
- Use photos of tinned peaches, wooden balls, cups or beans to help estimate portion sizes

VEGETABLES
- Fresh, frozen or Tinned (if tinned were they tinned with flavoured sauce/syrup/juice)
- Cooking method – boiled, baked (with fat/oil – what type and how much?), microwaved, steamed etc
- Colour – e.g. red/green capsicums
- Potatoes – with or without skin, if mashed what was added and how much?
- Quantities could be recorded in cups (sliced/whole/mashed/diced) or how much of a whole vegetable (e.g. ½ a medium capsicum)
- Use photos to help estimate portion size for similar vegetables not shown in pictures (e.g. broccoli can be used to estimate cauliflower, peas can be used for corn or bean etc). Use thickness guides and rulers to help estimate sliced vegetables (e.g. cucumber).

DAIRY
- Milk – brand name and fat content (show picture of bottle tops)
- Yoghurt – brand and with fruit or plain/natural or vanilla, reduced fat, low fat
- Ice cream – brand, any additions? If in a bowl use pictures to help estimate amounts.
- Cheese - - type (e.g. Edam, Colby, Feta), brand, grated (in cups or use pictures) or sliced (thickness guides)

NUTS
- Roasted, raw, salted, other favouring, blanched
- Whole, chopped, slivered
- Mixed – with or without peanuts
- How many cups or how many whole nuts? or can use beans to estimate handful size

BREAD
- White, wholemeal, wholegrain, light or dark rye (use photos to help with identification)
- Brand name (important for fortification)
- Toast or sandwich slice (thick or thin)
- For buns – any toppings (don't worry about small amounts of seeds, but do record cheese, bacon etc)

MARGARINE/BUTTER/TABLE SPREAD

- People often use the term butter and margarine interchangeably so collect the brand name (do not comment on the fact they might not have used the correct description)
- Low fat or standard
- Phytosterols (cholesterol reducing)
- Use pictures to help indication of thickness of spread

DRINKS

- Juices/Fruit Drinks
  - Terms used interchangeably so always collect brand information if possible
  - 100% juice or fruit drink
  - No sugar added or sweetened?
  - Added vitamins
  - Commercial or freshly squeezed
  - Did they dilute with water, is so how much
  - Use cups or pictures of cans and bottles to help estimate portion size

- Fizzy drinks
  - Brand
  - Flavour
  - Diet, standard, zero sugar, type of sweetener
  - Caffeinated
  - Use cups or pictures of cans and bottles to help estimate portion size
  -

- Made from liquid (cordial) or powdered concentrate (raro)
  - Brand and flavour details of concentrate
  - Standard or low energy/ low sugar version
  - How much concentrate?
  - Did they make it with water or something else?
  - How much water or other substance was added?

PACKAGED FOODS

- Brand and package size most important
- Did they consume everything in the packet?

MIXED DISHES

- Try and record recipe if possible
- If recipe unavailable try and get as much detail as possible
- Check any protein ingredients, starchy ingredients, vegetables, sauces

Use photos, cups, plates and bowls to estimate portion size

9.5 Appendix E. Daily data collection procedure

Daily data collection procedure

Prepared by: Jill
12/02/19

1. Report to the school office. If accelerometers are due to be collected, then set up the collection box at the office.

2. Set up data collection space. Put up SuNDiAL project signs where appropriate. Ensure you have your name badge on.

3. Put anthropometric equipment in a private space.

4. Set up clipboards with a **diet recall recording sheet** and an **anthropometric recording sheet** (at the back).

5. Greet your participant and take their name. Take time to develop rapport.

6. Check on the **Name & ID spreadsheet** that they have enrolled in the study.

7. If they have not then ask them to complete online enrolment by going to the SuNDiAL website, or checking their email for a link to enrol.

8. If they are not on your latest **Name & ID spreadsheet** but claim to have recently enrolled, give Tessa, Jill, or Meredith a quick call.

9. **You cannot collect any data from participants who haven't enrolled.**

10. Take the ID number next to their name and write it on the **diet recall recording sheet** and the **anthropometric recording sheet.**

11. Carry out the diet recall as per the **diet recall protocol**.

12. Undertake the anthropometric measures as per the **anthropometric protocol**

13. If the participant has opted to wear an accelerometer fit the accelerometer referring to the **accelerometer protocol** and give the participant guidance on how to complete the wear time log.

14. If they have opted to have blood and/or urine taken then book them in for a time on the **Blood booking sheet**. Give them an appointment card. If they would rather do the urine sample at home and drop it in, give them a takeaway pack.

15. Thank them very much for their participation and inform them that their voucher will be mailed to them on completion of data collection in their school.

16. Safely store data sheets in a place where they remain confidential (i.e. not just lying around).

17. At the end of the day, collect any accelerometers and logs from the collection box and pack up equipment (if necessary).

18. Store data sheets in a safe place.

19. Send text and/or email reminders about appointments the following day or about returning accelerometers and logs the next day**.**

9.6 Appendix F. Food List and Models

Department of Human Nutrition
University of Otago
PO BOX 56 Dunedin
New Zealand

Human Nutrition Department (2019)

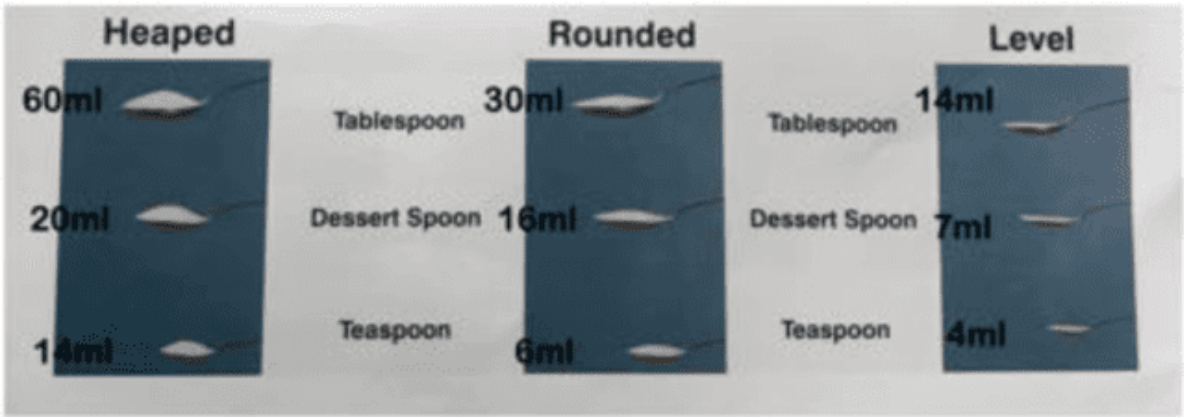
Baked beans
Broccoli
Cabbage
Carrots
Chips
Cornflakes
Grated cheese
Gravy
Ice cream
Mac and cheese
Mashed potato
Mixed vegetables
Noodles
Peas
Popcorn
Porridge
Rice
Scrambled eggs
Shepard's pie
Sliced chicken
Sliced meat
Spiral pasta
Tomato sauce

Food list with quantities

Coffee cups					
Heaped Spoons	60ml	30ml	14ml		
Dessert spoon	20ml	16ml	7ml		
Teaspoon	14ml	6ml	4ml		
Canned drinks	250ml	225ml	500ml	330ml	
Glass bottles	328ml	330ml	500ml		
Bread					
Milk tops	silver	yellow	Dark blue	Light blue	green
Muesli	25g	50g	75g	100g	
Peaches	23g	56g	138g	340g	
Cornflakes	32g	41g	55g	72g	
Porridge	11g	183g	278g	418g	
Porridge	111g	183g	278g	418g	
Margarine/butter	4g	5g	9g	12g	
Honey	10g	18g	25g	35g	
Jam	10g	18g	25g	35g	
Peanut butter	9g	12g	16g	30g	
Marmite	4g	5g	9g	12g	
Chickpea stew	130g	200g	250g	300g	
Tofu	41g	69g	109g	168g	
Stir fry	100g	182g	320g	480g	
Broccoli	17g	33g	66g	137g	
Peas	16g	31g	59g	112g	

Mixed vegetables	28g	44g	69g	109g	
Carrots	20g	37g	67g	122g	
Cabbage	14g	30g	67g	150g	
Mashed potato	102g	151g	223g	330g	
Sliced meat	30g	51g	87g	150g	
Sliced chicken	25g	50g	101g	204g	
Spaghetti	60g	100g	145g	224g	
Rice	54g	101g	191g	359g	
Noodles	92g	148g	246g	387g	
Spiral pasta	55g	101g	188g	350g	
Shepard's pie	43g	85g	168g	332g	
Baked beans	40g	81g	166g	337g	
Stew	100g	170g	260g	360g	
Mac & cheese	24g	52g	113g	243g	
Chips	70g	118g	198g	334g	
Ice cream	30g	54g	99g	180g	
Gravy	20g	41g	85g	175g	
Whittaker's chocolate	4g	22g	250g		
Cadbury	5g	25g	200g		
Lindt	10g	20g	100g		
Milky bar	5g	25g	200g		
Muffin	50g	130g	146g		
Nut bar	19g	22g	50g	35g	40g

Prepared by: Chaya R.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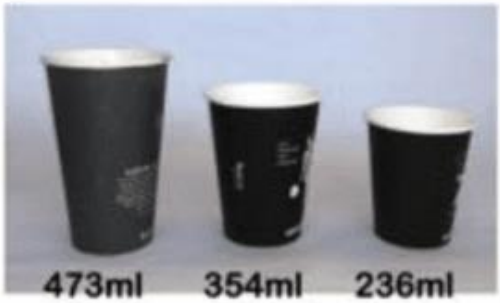
Dessert Spoon
16ml
Dessert Spoon
7ml
14ml
Teaspoon
6ml
Teaspoon
4ml


250ml 255ml 328ml 500ml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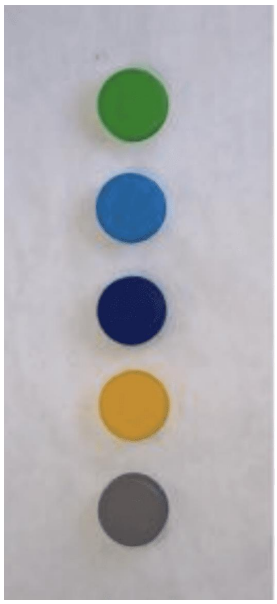
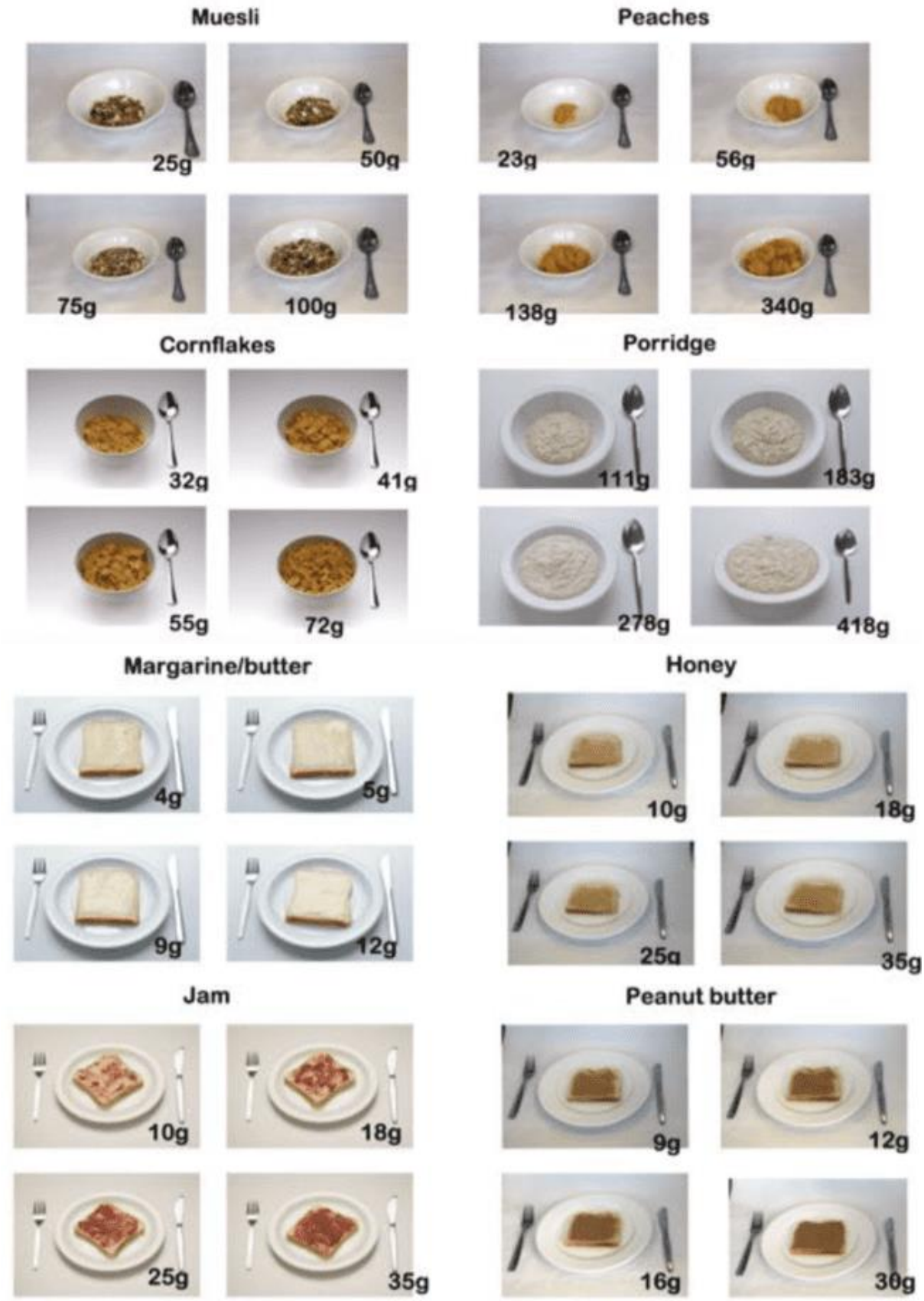
330ml 330ml 500ml




Muesli
25g
50g
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Peaches
23g
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138g
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Cornflakes
32g
41g
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72g
Porridge
111g
183g
278g
418g
Margarine/butter
4g
5g
9g
12g
Honey
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Jam
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Peanut butter
9g
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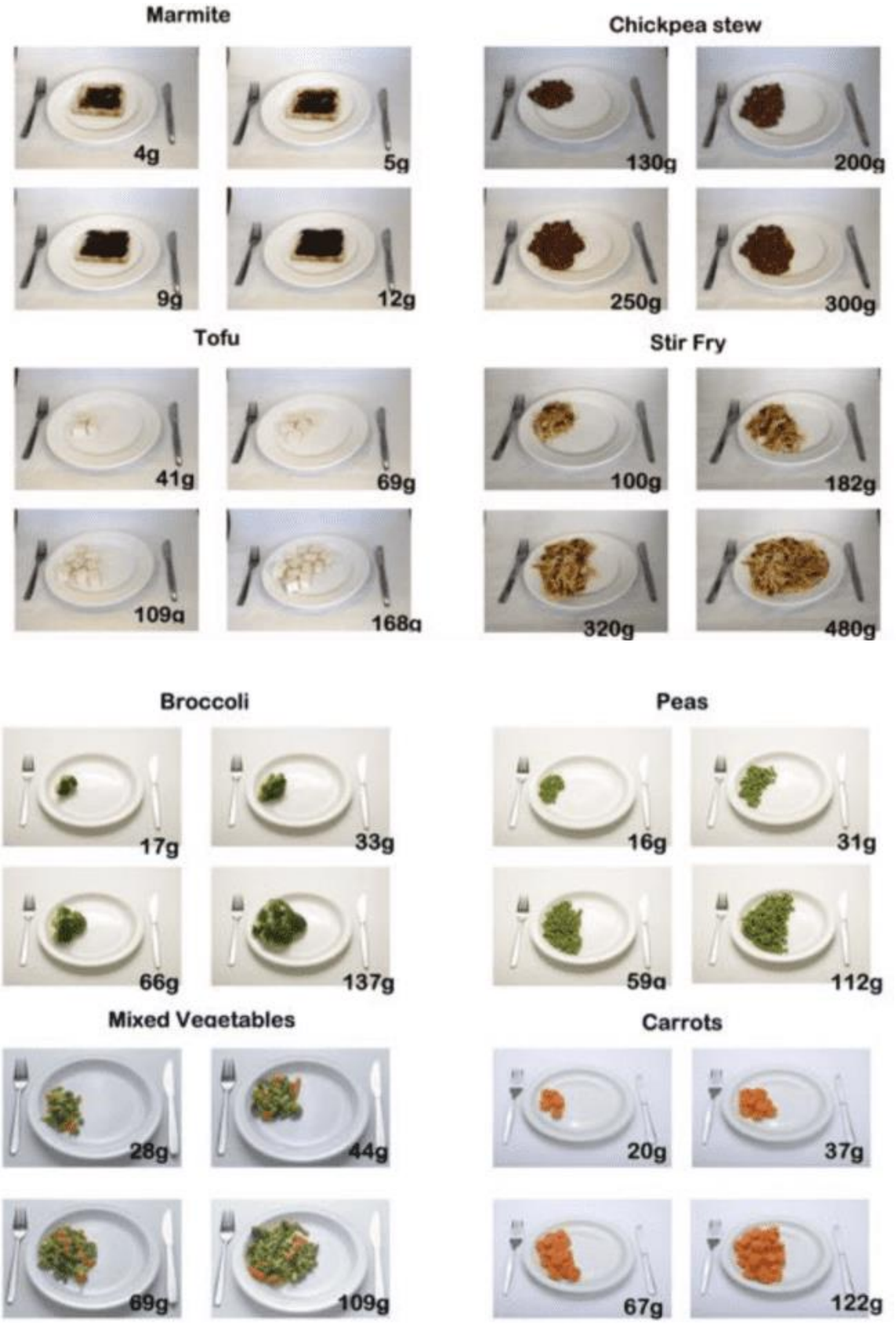
16g
30g


Marmite
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Chickpea stew
130g
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Tofu
41g
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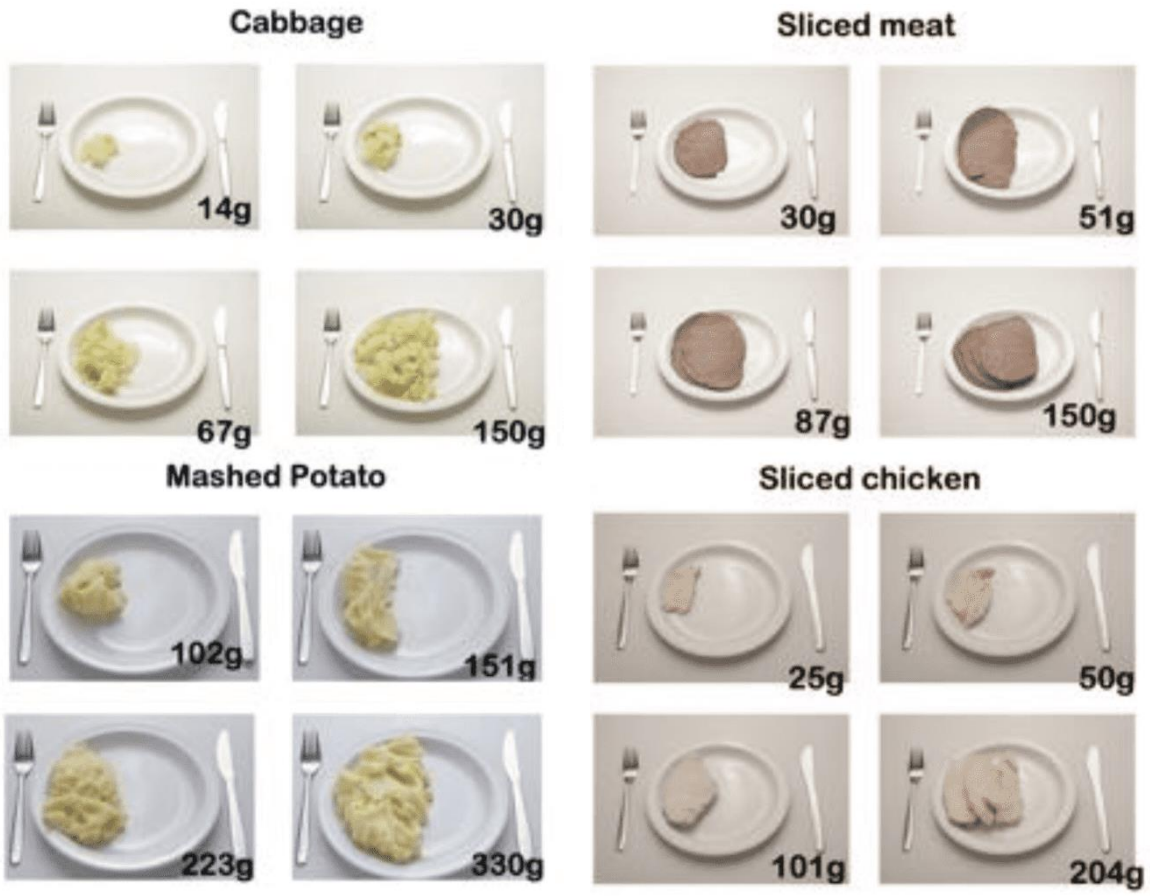
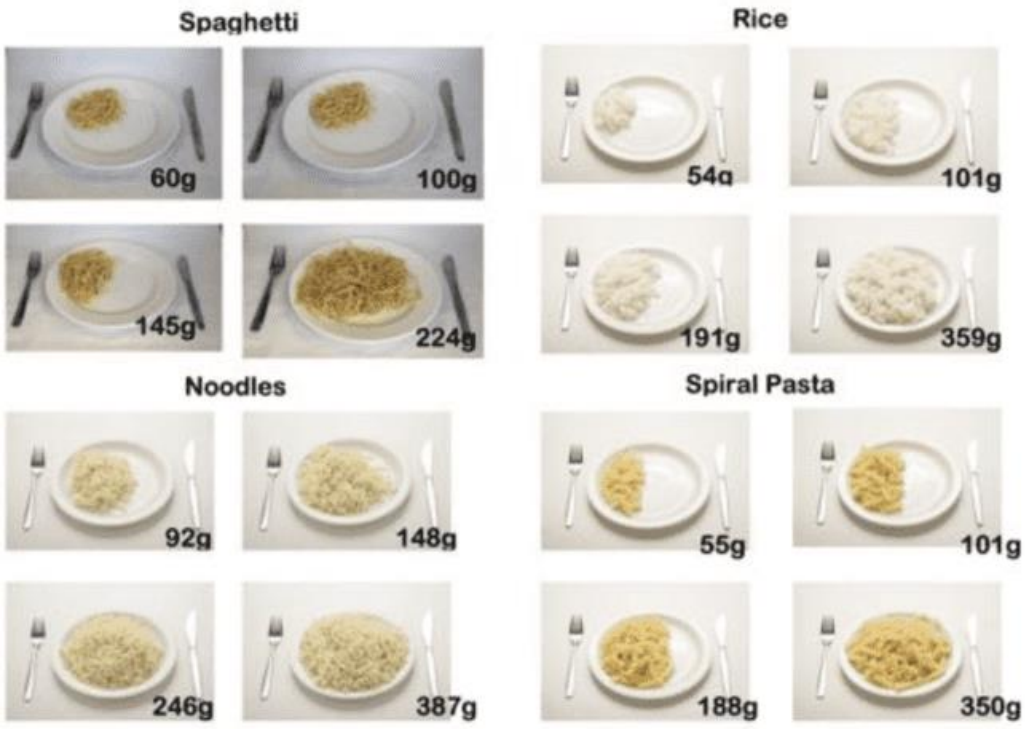
109g
168g
Stir Fry
100g
182g
320g
480g
Broccoli
17g
33g
66g
137g
Peas
16g
31g
59g
112g
Mixed Vegetables
28g
44g
69g
109g
Carrots
20g
37g
67g
122g


Cabbage
14g
30g
67g
150g
Sliced meat
30g
51g
87g
150g
Mashed Potato
102g
151g
223g
330g
Sliced chicken
25g
50g
101g
204g


Spaghetti
60g
100g
145g
224g
Rice
54g
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Noodles
92g
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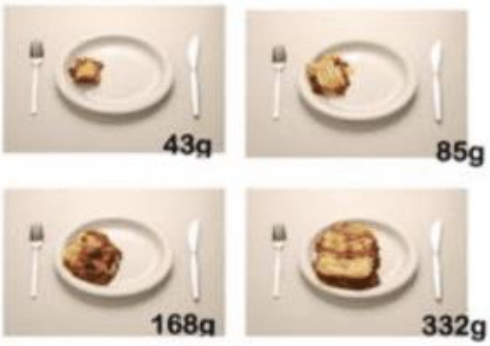
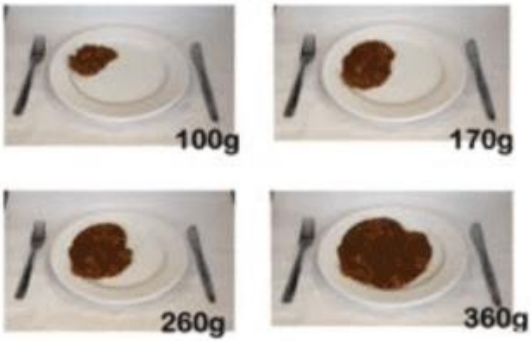
Spiral Pasta
55g
101g
188g
350g

Shepards Pie



Stew



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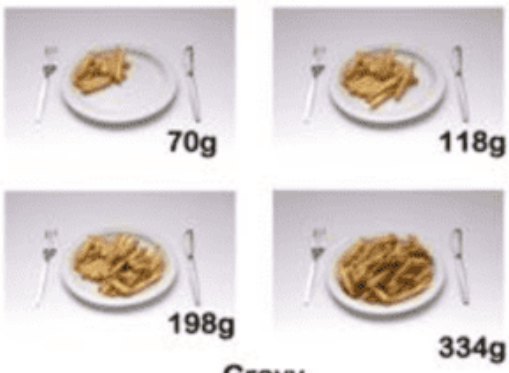
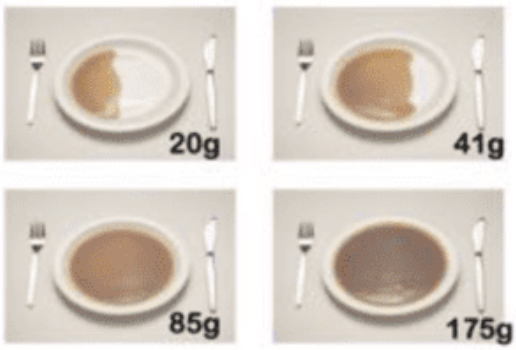
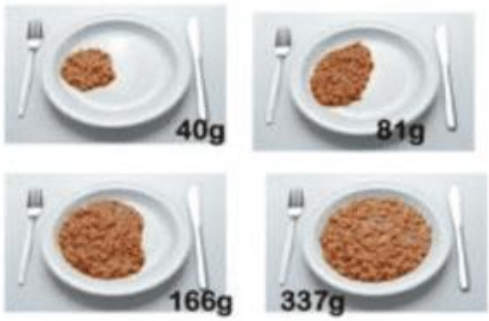


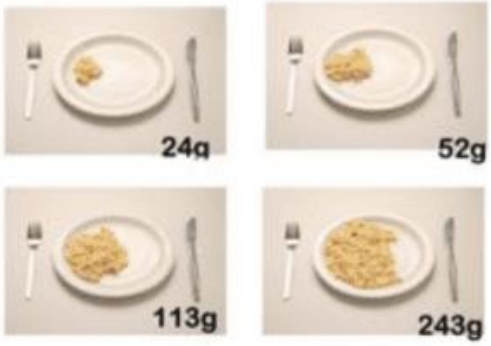
Gravy



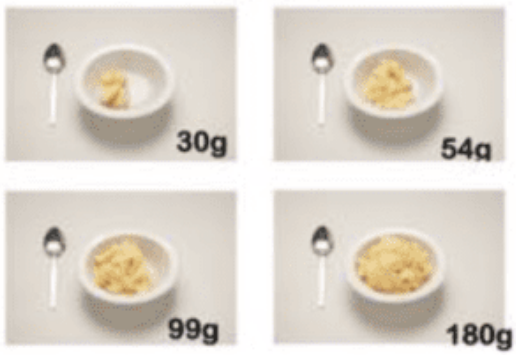
Baked Beans

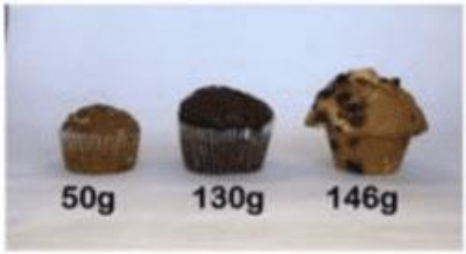


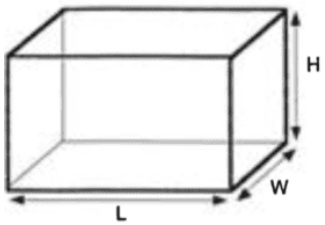
Mac & cheese



Ice cream







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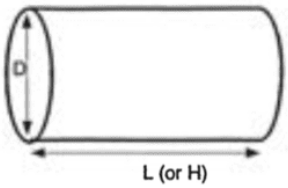

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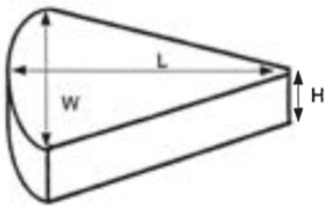

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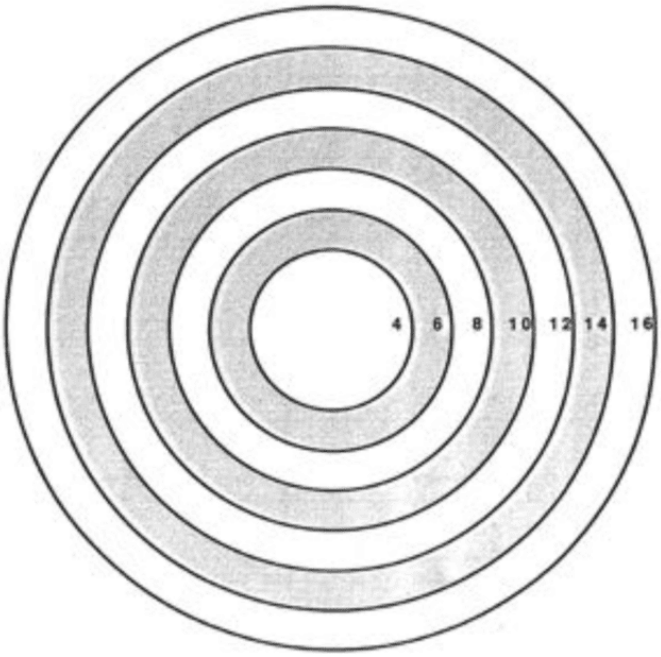
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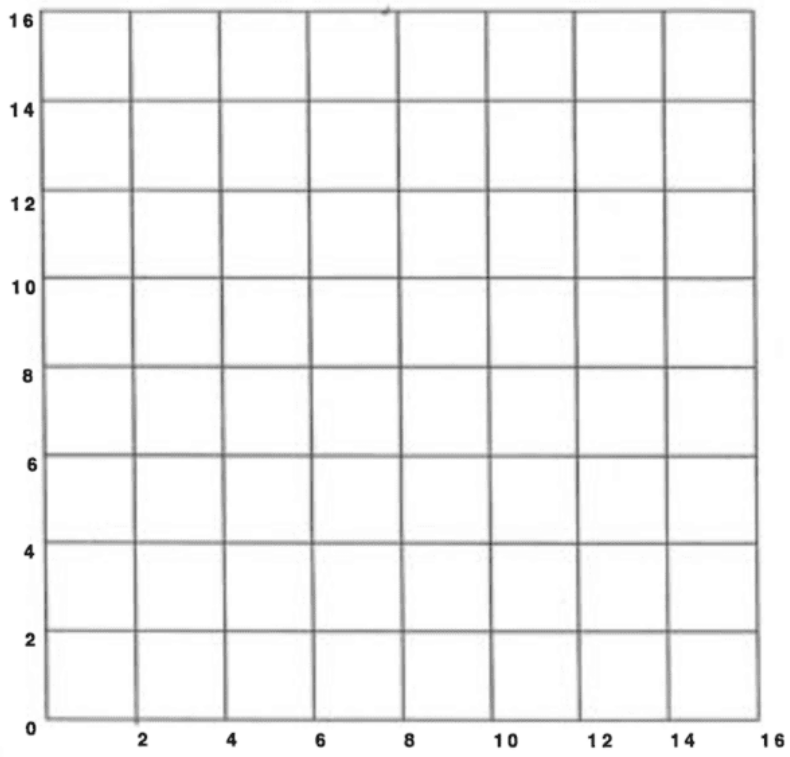
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9.7 Appendix G. Enrolment Questionnaire

Confidential

SuNDiAL 2019 Enrolment Questionnaire

Thank you for showing an interest in this project. Please read the information about SuNDiAL project carefully. This can be found on our website www.otago.ac.nz/sundial. Take time to think about it and talk with family or friends before you decide whether to take part or not. If you decide to take part we thank you. If you decide not to take part that won't disadvantage you and we thank you for considering it.

Who are we seeking to take part in the project?
We are looking for female high school students who are 15 to 18 years old. To be eligible to take part, your high school must have agreed to take part in the study, you must speak and understand English, and be able to complete the questionnaires.

If you take part, what will you be asked to do?
If you agree to take part in this study you will be asked to do three things:

1) Complete an online questionnaire with three parts to it: (i) health & demographics; (ii) why you choose the food you eat; and (iii) your dietary habits.

2) Attend a session at your school with our research team. This visit will take about 60 minutes and you will be asked to recall the food and drink you've consumed over the last day. You will also have your height, weight, and length of your lower arm measured. These measurements will be done twice to make sure they are as accurate as possible. This will be done in a private space and you may ask for the measurements if you want them.

3) In the next week or two we'll ring or video call you to do a second food and drink recall.

Any questions?

Contact Jill (ph 03 479 5683) or Meredith (ph 03 479 8157) or email us on: sundial@otago.ac.nz

This study has been approved by the University of Otago Human Ethics Committee (Health). If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (phone +64 3 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

You have had all your questions answered about the study and understand that you can ask for more information at any stage

You know that when the project is completed all personal information that could be linked to you will be removed from the paper records and electronic files for the project, and that these will be placed in secure storage and kept for at least ten years.

You are a young woman who is 15 to 18 years old and isn't pregnant

You know you can pull out of the study anytime before it finishes in October 2019.

If you don't want to take part in the SuNDiAL project, please click on the "disagree" button.

◯ AGREE
◯ DISAGREE

Thank you for agreeing to taking part in the SuNDiAL project! If you are female, aged 15-18 years of age and not pregnant, please answer the following two questions:

What age are you as of today?	◯ 15 ◯ 16 ◯ 17 ◯ 18 ◯ None of the above
What high school do you attend?	◯ Tauraroa Area School ◯ Mt Maunganui College ◯ Spotswood College ◯ Wellington Girls College ◯ Waimea College ◯ Hornby High School ◯ Columba College ◯ Kaikorai Valley College ◯ Queens High School ◯ Mt Aspiring College ◯ None of the above

Thank you! You are eligible to take part in the SuNDiAL project!

There are three other parts to the SuNDiAL project that are optional. Please read the following information carefully before you decide whether to take part in these optional bits of the study. For each one of these that you do, you will receive a $5 gift voucher from New World or PaknSave.

If you agree to do these, but change your mind later, that's OK - there is no disadvantage to not you if you decide not to do these.

Once all of the analysis has been completed the samples will be disposed of using standard biohazard protocols. On the consent form (below) you can tell us if you would like your blood sample disposed of with a Karakia (Māori Prayer).

Electronic consent

Click on the "AGREE" button below if:
- You have read the information on the website
- You want to take part in these parts of the study

If you don't want to take part in these parts of the study, please click on the "DISAGREE" button.

BLOOD SAMPLE:

We would like you to provide a blood sample (which would be collected by someone with extensive training in how to collect blood), but we understand that not everyone feels comfortable about this so it is entirely up to you if you do this. If you do provide a blood sample, we can tell you whether you're iron deficient or not. You can still take part in the rest of the study even if you don't do this bit.

Click on the agree button below if:

You understand the risks of discomfort involved in providing a blood sample

◯ AGREE
◯ DISAGREE

Please click here if you want your samples disposed of with a Karakia (Māori Prayer)

◯ Yes
◯ No

URINE SAMPLE:

We would also like you to give a urine sample ("pee or wee") - which is easy for you collect yourself with the equipment we give you. You can still take part in the rest of the study even if you don't do this bit.

Click on the 'AGREE' button below if:

◯ AGREE
◯ DISAGREE

ACCELEROMETER:

We would also like you to wear a small red box called an accelerometer on an elastic belt 24 hours a day for seven days. This will tell us how much time you spend sitting down, moving around, and sleeping. If you choose to wear the accelerometer you will be asked to complete a little diary about the times your took the device off, and what time you went to bed each night on the days that you wear it.

One of our research team will return to your school the week after this visit to collect the accelerometer. You can still take part in the rest of the study even if you don't do this bit.

◯ AGREE
◯ DISAGREE

Contact Information

What is your name?	_____ (Preferred first name, Last name)
What is your date of birth?	_____
Age	_____
Phone number (mobile would be best - so we can text you reminders)	_____
What is your home address? (This will be the address where we will send your voucher)	_____ (number & street, suburb, city, postcode)
Do you live at this address during school term?	◯ Yes ◯ No
Do you live in a boarding house during school term? (Don't include private boarding)	◯ Yes ◯ No
Please put the name and/or address of the boarding house	_____ (number & street, suburb, city, postcode)
What is the address that you live at during school term?	_____ (number & street, suburb, city, postcode)

Health Information

If you know your height, please write it here:	_____
What unit is this measurement in?	◯ centimetres ◯ metres ◯ feet and inches
If you know your weight (in kg) please write it here:	_____

Have you been diagnosed with diabetes?	◯ Yes ◯ No
If so, which type?	◯ Type 1 diabetes ◯ Type 2 diabetes ◯ Don't know
Do you avoid eating gluten?	◯ Yes ◯ No
Have you been diagnosed with either coeliac disease or gluten intolerance?	◯ Yes - coeliac disease ◯ Yes - gluten intolerant ◯ No diagnosis but suspected intolerance or coeliac ◯ No
Have you been diagnosed with a food allergy or intolerance? (not gluten)	◯ Yes ◯ No
Which foods are you allergic or intolerant to? (Select as many as apply)	☐ Eggs ☐ Dairy ☐ Nuts ☐ Shellfish ☐ Other
Other: please specify	_____
Are you vegetarian or vegan?	◯ Yes ◯ No
Which foods do you eat? (Select as many as apply)	☐ Egg ☐ Milk (not plant milk like soy milk) ☐ Fish or seafood ☐ Chicken or poultry ☐ Meat/red meat occasionally ☐ None of the above
Are you vegan?	◯ Yes ◯ No
How long have you been following this way of eating?	◯ Less than a month ◯ Between 1 and 6 months ◯ Between 6 months and 1 year ◯ Between 1 and 2 years ◯ More than 2 years ◯ My whole life

The following questions are a bit sensitive, but it is necessary for us to ask them because they can help us understand what nutrients are important for the health of young women your age

How old were you when you had your first period?	◯ 11 years or younger ◯ 12-14 years ◯ 15 years or older ◯ I haven't had a period yet
How long do you usually have from the start of one period to the start of the next?	◯ Less than a week ◯ 1-2 weeks ◯ 3-4 weeks ◯ 4-5 weeks ◯ More than 5 weeks ◯ I haven't had a period for 3 months ◯ The timing of my periods is not regular
How many days does your period usually last? (count your light days as well as your heavy ones)	◯ Less than 4 days ◯ 4-6 days ◯ 7-9 days ◯ 10 days or more
Are your periods so heavy that they make it hard for you to go to school?	◯ Yes - often ◯ Yes - sometimes ◯ No
Have you donated blood?	◯ Yes ◯ No
When did you last donate blood?	◯ In the last 4 months ◯ Between 4 and 12 months ago ◯ More than a year ago
Have you had a nosebleed in the last year?	◯ Yes ◯ No
Do you have nosebleeds regularly?	◯ Yes ◯ No
Over the last year, on average how often did you get nose bleeds?	◯ More than once a week ◯ Once a week ◯ Every couple of weeks ◯ Once a month ◯ Every few months ◯ Every 6 months ◯ Once a year ◯ Less than once a year
Do you use any of the following contraceptives: - Oral contraceptive (eg 'the pill' or 'the mini-pill') - Depo Provera injection - Implant (eg Jadelle) - Hormonal IUD (eg Mirena)	◯ No - I don't use those contraceptives ◯ Yes - I use one of those contraceptives

Other information

Which ethnic group do you belong to? (Mark those that apply)	☐ New Zealand European ☐ Māori ☐ Samoan ☐ Cook Island Maori ☐ Tongan ☐ Niuean ☐ Chinese ☐ Indian ☐ Other such as Dutch, Japanese, Tokelauan, please state..
Other: please state	_____
Please let us know which type of gift card you would prefer:	◯ New World ◯ PaknSave

Thank you for enrolling in the SuNDiAL project!

What happens next?

We are now going to ask you to complete a questionnaire about why you eat the food you do. If you want to complete it at a later time, please click the Save and Return button at the bottom of this page (don't forget to make a note of your code so that you can return to this survey). Or, click the "Submit" button to continue.

You will also get an email and/or text to tell you when you can visit the SuNDiAL clinic at your school to complete the other measurements.

9.8 Appendix H. Dietary Habits Questionnaire

Confidential

Dietary Habits Questionnaire

Fruit

On average how many servings of fruit - fresh, frozen, canned or stewed - do you eat per day or per week?
Do not include fruit juice or dried fruit.

A serving is the same as a medium piece of fruit like an apple or two small pieces of fruit like two apricots, or half a cup of stewed or canned fruit.

- ◯ Never I don't eat fruit
- ◯ Less than 1 serving a week
- ◯ 1 serving a week
- ◯ 2-4 servings a week
- ◯ 5-6 servings a week
- ◯ 1 serving a day
- ◯ 2 servings a day
- ◯ 3 servings a day
- ◯ More than 3 servings a day

Confidential

Vegetables

On average how many servings of vegetables - fresh, frozen or canned - do you eat per day or per week?
Do not include vegetable juices.

A serving is the same as one potato, half a cup of peas or a cup of salad.

- ◯ Never I don't eat vegetables
- ◯ Less than 1 serving a week
- ◯ 1 serving a week
- ◯ 2-4 servings a week
- ◯ 5-6 servings a week
- ◯ 1 serving a day
- ◯ 2 servings a day
- ◯ 3 servings a day
- ◯ More than 3 servings a day

Bread

On average how often do you eat bread?

Include slices of bread, rolls, bagels, wraps, and gluten-free bread.

- ◯ Never I don't eat bread
- ◯ Less than once a week
- ◯ Once a week
- ◯ 2-4 times a week
- ◯ 5-6 times a week
- ◯ Once a day
- ◯ Twice a day
- ◯ 3 times a day
- ◯ More than 3 times a day

What type of bread, rolls or toast do you eat most of the time?

- ◯ White
- ◯ Wholemeal (brown colour)
- ◯ Light grain - has some grains but soft to eat (eg honey grain)
- ◯ Heavy grain - has some grains and a bit chewier (eg Vogels)
- ◯ Other (please specify)

If Other, please specify:

_____

Milk

How often do you have milk (cow's milk or plant milk)?

- ◯ I do not have any milk
- ◯ Rarely
- ◯ Monthly
- ◯ 2-3 times a month
- ◯ Once a week
- ◯ 2-4 times a week
- ◯ 5-6 times a week
- ◯ Once a day
- ◯ More than once a day

What type of milk do you use the most of?

- ◯ None
- ◯ Cow's milk
- ◯ Plant-based milk (eg soy, rice, almond, coconut)
- ◯ Other (such as goat or sheep milk)

What kind of milk do you usually have?

- ◯ Whole or standard milk (Dark blue or silver)
- ◯ Reduced fat (light blue)
- ◯ Skim or trim (green or yellow)
- ◯ Other (please specify)

If Other, please specify:

_____

What kind of milk do you usually have?

- ◯ Regular
- ◯ Lite
- ◯ Sweetened or flavoured

Spreads and Oils

What type of spread do you use the most of?

- ◯ None
- ◯ Butter (including semi soft)
- ◯ Margarine (eg Canola, Sunflower, Olive oil based, or table spread)
- ◯ Other (eg avocado, cream cheese), please specify
- ◯ I don't know

If other, please specify:

_____

What type of fat or oil is used most often in cooking in your household?

- ◯ None
- ◯ Butter
- ◯ Coconut oil
- ◯ Margarine
- ◯ Oil (eg Olive, Canola, or one in a bottle)
- ◯ Dripping or Lard
- ◯ I don't know

Nuts

How often do you eat the following types of nuts? (Include nuts in cooked foods, bars, cereals etc but don't include peanut butter or other nut butters)

	More than once a day	Once a day	5-6 times a week	2-4 times a week	Once a week	2-3 times a month	Monthly	Rarely	I do not eat these
Almonds	○	○	○	○	○	○	○	○	○
Brazil	○	○	○	○	○	○	○	○	○
Cashew	○	○	○	○	○	○	○	○	○
Hazelnut	○	○	○	○	○	○	○	○	○
Macadamia	○	○	○	○	○	○	○	○	○
Peanut	○	○	○	○	○	○	○	○	○
Pecan	○	○	○	○	○	○	○	○	○
Pine nut	○	○	○	○	○	○	○	○	○
Pistachio	○	○	○	○	○	○	○	○	○
Walnut	○	○	○	○	○	○	○	○	○
Other	○	○	○	○	○	○	○	○	○

How often do you eat nut butters?

	More than once a day	Once a day	5-6 times a week	2-4 times a week	Once a week	2-3 times a month	Monthly	Rarely	I don't eat this type of nut butter
Almond butter	○	○	○	○	○	○	○	○	○
Cashew butter	○	○	○	○	○	○	○	○	○
Hazelnut butter	○	○	○	○	○	○	○	○	○
Peanut butter	○	○	○	○	○	○	○	○	○
Walnut butter	○	○	○	○	○	○	○	○	○
Other	○	○	○	○	○	○	○	○	○

Meat, Dairy and Eggs

How often do you eat each of the following foods:

	More than once a day	Once a day	5-6 times a week	2-4 times a week	Once a week	2-3 times a month	Monthly	Rarely	I do not eat this
Egg	○	○	○	○	○	○	○	○	○
Cow's milk	○	○	○	○	○	○	○	○	○
Dairy products excluding milk (eg cheese, yoghurt - don't include plant based)	○	○	○	○	○	○	○	○	○
Processed meat (eg ham, bacon, sausages, luncheon, canned corned beef, pastrami, salami)	○	○	○	○	○	○	○	○	○
Other red meat (including beef, lamb, venison etc don't include processed meat)	○	○	○	○	○	○	○	○	○
Pork	○	○	○	○	○	○	○	○	○
Poultry (including chicken, turkey etc)	○	○	○	○	○	○	○	○	○
Fish	○	○	○	○	○	○	○	○	○
Other seafood/shellfish (eg prawns, squid, crab)	○	○	○	○	○	○	○	○	○

Legumes

How often do you eat lentils, chickpeas, kidney beans or baked beans? (Don't include peas or peanuts)

○ I do not eat legumes
○ Rarely ○ Monthly ○ 2-3 times a month ○ Once a week
○ 2-4 times a week ○ 5-6 times a week
○ Once a day ○ More than once a day

Other Foods	
How often do you eat tofu, tempeh and tofu products?	◯ I do not eat these ◯ Rarely ◯ Monthly ◯ 2-3 times a month ◯ Once a week ◯ 2-4 times a week ◯ 5-6 times a week ◯ Once a day ◯ More than once a day
How often do you eat vegetarian ingredients (like quorn, nut meat, vegetarian mince) that are used in other dishes?	◯ I do not eat these ◯ Rarely ◯ Monthly ◯ 2-3 times a month ◯ Once a week ◯ 2-4 times a week ◯ 5-6 times a week ◯ Once a day ◯ More than once a day
How often do you eat vegetarian sausages, nuggets, patties etc?	◯ I do not eat vegetarian meat alternatives ◯ Rarely ◯ Monthly ◯ 2-3 times a month ◯ Once a week ◯ 2-4 times a week ◯ 5-6 times a week ◯ Once a day ◯ More than once a day
How often do you eat vegetarian "meat alternatives" (like chicken-free chicken, vegetarian chicken schnitzel, meat-free bacon rashers etc)?	◯ I do not eat these ◯ Rarely ◯ Monthly ◯ 2-3 times a month ◯ Once a week ◯ 2-4 times a week ◯ 5-6 times a week ◯ Once a day ◯ More than once a day

Sweet Drinks	
How often do you drink diet or drinks labelled "sugar-free"?	◯ I do not drink diet or sugar-free drinks ◯ Rarely ◯ Monthly ◯ 2-3 times a month ◯ Once a week ◯ 2-4 times a week ◯ 5-6 times a week ◯ Once a day ◯ More than once a day
How often do you drink fizzy drinks? Don't include diet varieties. (eg Coca-cola, Pepsi, lemonade)	◯ I do not drink fizzy drinks ◯ Rarely ◯ Monthly ◯ 2-3 times a month ◯ Once a week ◯ 2-4 times a week ◯ 5-6 times a week ◯ Once a day ◯ More than once a day
How often do you drink fruit juices, drinks or cordials? (eg Just Juice, Fresh-up, Keri, Golden Circle, Ribena, Charlie's, Raro). Don't include diabetic, diet or sugar-free varieties.	◯ I do not drink juice or cordial ◯ Rarely ◯ Monthly ◯ 2-3 times a month ◯ Once a week ◯ 2-4 times a week ◯ 5-6 times a week ◯ Once a day ◯ More than once a day
How often do you drink energy drinks? (eg V, Lift plus, Red Bull, Powerade)	◯ I do not drink energy drinks ◯ Rarely ◯ Monthly ◯ 2-3 times a month ◯ Once a week ◯ 2-4 times a week ◯ 5-6 times a week ◯ Once a day ◯ More than once a day

Snacks

How often do you eat lollies, sweets, chocolate or confectionary?

- ◯ I do not eat these
- ◯ Rarely
- ◯ Monthly
- ◯ 2-3 times a month
- ◯ Once a week
- ◯ 2-4 times a week
- ◯ 5-6 times a week
- ◯ Once a day
- ◯ More than once a day

How often do you eat biscuits, cakes, slices, muffins, sweet pastries or muesli bars?

Include nut and other sweet snack bars.

- ◯ I do not eat these
- ◯ Rarely
- ◯ Monthly
- ◯ 2-3 times a month
- ◯ Once a week
- ◯ 2-4 times a week
- ◯ 5-6 times a week
- ◯ Once a day
- ◯ More than once a day

How often do you eat savoury snacks such as chips (crisps not hot chips) and crackers?

- ◯ I do not eat these
- ◯ Rarely
- ◯ Monthly
- ◯ 2-3 times a month
- ◯ Once a week
- ◯ 2-4 times a week
- ◯ 5-6 times a week
- ◯ Once a day
- ◯ More than once a day

Fast Food

How often do you eat fast food or takeaways from places like McDonalds, KFC, Burger King, Pizza shops or fish and chip shops?

- ◯ I do not eat fast food
- ◯ Rarely
- ◯ Monthly
- ◯ 2-3 times a month
- ◯ Once a week
- ◯ 2-4 times a week
- ◯ 5-6 times a week
- ◯ Once a day
- ◯ More than once a day

How often do you eat pies and other hot food that you buy ready-to-eat?

- ◯ I do not eat these
- ◯ Rarely
- ◯ Monthly
- ◯ 2-3 times a month
- ◯ Once a week
- ◯ 2-4 times a week
- ◯ 5-6 times a week
- ◯ Once a day
- ◯ More than once a day

Breakfast Consumption

How many days in an average week do you have something to eat for breakfast?

- ◯ I don't usually have breakfast
- ◯ 1 day a week
- ◯ 2 days a week
- ◯ 3 days a week
- ◯ 4 days a week
- ◯ 5 days a week
- ◯ 6 days a week
- ◯ 7 days a week

Supplement Use

Did you take any supplements during the last year?

- ◯ Yes
- ◯ No

What type of supplement was it? (Select as many as apply)

- ☐ Multivitamin and/or multimineral
- ☐ Single vitamin or mineral
- ☐ Oil
- ☐ Bran
- ☐ Lecithin
- ☐ LSA
- ☐ Kelp
- ☐ Spirulina
- ☐ Glucosamine and/or chondroitin
- ☐ Echinachea
- ☐ Ginkgo
- ☐ Hypericum (St John's Wort)
- ☐ Sports supplement
- ☐ Other (please specify)

Multivitamin and/or multimineral: How long did you take the supplement in the last 12 months?

- ◯ Daily
- ◯ More than once a week
- ◯ Once per week
- ◯ Monthly
- ◯ Regularly but for a limited time
- ◯ Not very often

Multivitamin and/or multimineral:

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

_____

Multivitamin and/or multimineral:

If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time).

When taking a photo (or two), please make visible the brand and the list of contents.

Single vitamin or mineral: Please tell us what vitamin or mineral it was:

_____

Single vitamin or mineral: How long did you take the supplement in the last 12 months?

- ◯ Daily
- ◯ More than once a week
- ◯ Once per week
- ◯ Monthly
- ◯ Regularly but for a limited time
- ◯ Not very often

Single vitamin or mineral:

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

_____

Single vitamin or mineral: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	
Please specify the type of oil:	_____
Oil: How long did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Oil: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____
Oil: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	
Bran: How long did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Bran: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____
Bran: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	

Lecithin: How long did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Lecithin: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____
Lecithin: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	
LSA: How long did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
LSA: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____
LSA: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	
Kelp: How long did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Kelp: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____

Kelp: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	
Spirulina: How long did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Spirulina: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____
Spirulina: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	
Glucosamine and/or chondroitin: How long did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Glucosamine and/or chondroitin: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____
Glucosamine and/or chondroitin: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	

Echinachea: How long did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Echinachea: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____
Echinachea: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	
Ginkgo: How long did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Ginkgo: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____
Ginkgo: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	
Hypericum (St John's Wort): How long did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Hypericum (St John's Wort): If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____

Hypericum (St John's Wort):

If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time).

When taking a photo (or two), please make visible the brand and the list of contents.

Sports supplement: How long did you take the supplement in the last 12 months?

- ◯ Daily
- ◯ More than once a week
- ◯ Once per week
- ◯ Monthly
- ◯ Regularly but for a limited time
- ◯ Not very often

Sports supplement:

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

_____

Sports supplement:

If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time).

When taking a photo (or two), please make visible the brand and the list of contents.

If Other, please specify:

_____

Other: How long did you take the supplement in the last 12 months?

- ◯ Daily
- ◯ More than once a week
- ◯ Once per week
- ◯ Monthly
- ◯ Regularly but for a limited time
- ◯ Not very often

Other:

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

_____

Other:

If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time).

When taking a photo (or two), please make visible the brand and the list of contents.

Do you have any comments about this survey?

Please add any comments you may have about this questionnaire here:

_____

9.9 Appendix I. List of contribution of calcium from different food groups

Percentage of contribution of calcium from different food groups

	Total Sample		Omnivores (n=219)		Vegetarian (n=31)	
Food Group	Mean %	(95% CI)	Mean %	(95% CI)	Mean %	(95% CI)
Grains and Pasta	5	(4,6)	5	(3.7, 6.2)	6	(3.3, 9.2)
Bread	8	(6.7, 8.8)	8	(6.5, 8.7)	8	(5.4, 10.5)
Breakfast Cereal	2	(1.5, 3.5)	3		2	
Biscuits	2	(1.2, 1.9)	2		1	
Cakes and Muffins	2	(1.9, 3)	2		3	
Bread based dished	8	(5.8, 9.7)	8	(5.8, 10.0)	7	(1.4, 12.3)
Puddings/deserts	0	(0.1, 0.7)	0		1	
Milk	17	(15, 19.7)	17	(14.5, 19.4)	19.5	(11.8, 27.3)
Dairy Products	5	(4.0, 6.3)	6	(4.2, 7.0)	2	(0.7, 4.1)
Cheese	13	(10.6, 15.3)	13	(10.6, 15.3)	11	(4.2, 18.2)
Butter and Margarine	0	(0,0)	0		0	
Fats and Oils	0	(0,0)	0		0	
Eggs and Egg dishes	1	(0.8, 1.7)	1		0	
Beef and Veal	0	(0, 0)	0		0	
Lamb/Mutton	0	(0, 0)	0		0	
Pork	0	(0, 0)	0		0	
Poultry	1	(1.1, 1.9)	2		0	
Other Meat	0	(0, 0)	0		0	
Sausages and Processed Meat	1	(0.4, 1.1)	1		1	
Pies and Pasties	1	(0.6, 1.6)	1		0	
Fish and Seafood	1	(0.3, 0.8)	1		0	
Vegetables	7	(6.1, 8.7)	7	(5.3, 7.8)	13	(8.1, 18.6)
Potatoes, Kumara and Taro	1	(1.2, 1.8)	1		1	
Snack Foods	1	(0.6, 1.5)	1		1	
Fruit	3	(2.5, 3.6)	3	(2.4, 3.5)	4	(2.1, 5.2)
Nuts and Seeds	2	(1.1, 2.2)	2		2	
Sugar/Sweets	2	(1.8, 3.2)	2		3	
Soups and Stocks	1	(0.2, 0.9)	1		1	
Savoury sauces and Condiments	1	(0.9, 1.9)	1		2	
Non-alcoholic beverages	8	(7.1, 9)	8	(7.0, 9.2)	7	(5.7, 9.3)
Alcoholic Beverages	0	(0, 0)	0		0	
Supplements providing energy	2	(1.2, 3.2)	2		2	
Snacks sweet	1	(1, 1.7)	1		1	

CI, confidence interval for top 9 food groups